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p.344, line 27

for: ***Collybiopsis subnuda*** (Ellis ex Peck) R.H. Petersen, comb. nov
IF 556198
Basionym: *Marasmius subnudus* Ellis ex Peck, 1898.
Bull. Torrey Bot. Club 25: 287.
[An invalid combination due to incorrect basionym citation]

read: ***Collybiopsis subnuda*** (Ellis ex Peck) R.H. Petersen, comb. nov.
IF 556112
Basionym: *Marasmius subnudus* Ellis ex Peck, 1898.
Ann. Rep. New York St. Mus. 51: 287. 1898.
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Mycotaxon *for* July–September 2020 (i–xii + 545–692)
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Nomenclatural novelties and typifications proposed in Mycotaxon 136(4)

Agaricus cespitosus Bolton 1836 (lectotypified),
[MBT 10004616], p. 792

Agaricus oniscus Fr. 1818 (lectotypified),
[MBT 10004612], p. 802 & (epitypified)
[MBT 10004614], p.802

Agaricus sphagnicola Berk. 1836 (neotypified),
[MBT 10004615], p. 814

Architrypethelium barrerae Guzm.-Guill. & Llar.-Hern.
[MB 837958], p. 750

Aspicilia lixianensis Q. Ren & Lin Liu
[FN 570763], p. 744

Aspicilia nivalis Q. Ren & Lin Liu
[FN 570764], p. 745

Aspicilia pycnocarpa Q. Ren & Lin Liu
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[MB 832680], p 728

Flavodontia C.L. Zhao
[MB 838322], p. 760

Flavodontia rosea C.L. Zhao
[MB 838323], p. 762

Lamprospora benkertii Eckstein, M. Vega, Sochorová & Janošík
[MB 831135], p. 696

Lepra taiwanensis Q. Ren
[FN 570770], p. 782

Lepra yunlingensis Q. Ren
[FN 570769], p. 780

Peronospora coronillae-minimae Vienn.-Bourg. ex W.J. Davis & J.A. Crouch
[MB 838139], p. 786
"*Peronospora coronillae-minimae*" Vienn.-Bourg., nom. inval.

Peronospora erini Vienn.-Bourg. ex W.J. Davis & J.A. Crouch
[MB 838140], p. 786
"*Peronospora erinii*" Vienn.-Bourg., nom. inval.

Peronospora papaveris-pilosi Vienn.-Bourg. ex W.J. Davis & J.A. Crouch
[MB 838141], p. 787
"*Peronospora papaveris-pilosi*" Vienn.-Bourg., nom. inval.

Peronospora ranunculi-flabellati Vienn.-Bourg. ex W.J. Davis & J.A. Crouch
[MB 838142], p. 787
"*Peronospora ranunculi-flabellati*" Vienn.-Bourg., nom. inval.

Peronospora viciicola L. Camp. ex W.J. Davis & J.A. Crouch
[MB 838143], p. 787
"*Peronospora viciicola*" L. Camp. [as '*vicicola*'] nom. inval.

Pertusaria wui Q. Ren
[FN 570761], p. 720

Pseudodeightoniella S.K. Verma, Sanj. Yadav & Raghv. Singh
[MB 836237], p. 772

Pseudodeightoniella indica S.K. Verma, Sanj. Yadav & Raghv. Singh
[MB 836238], p. 772

Reviewers — volume one hundred thirty-six (4)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this issue.

Sabeena Aliyarukunju
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2022 Mycotaxon submission procedure

Prospective Mycotaxon authors should download the Mycotaxon 2022 guide, review & submission forms, and Mycotaxon sample manuscript by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. This page briefly summarizes our '4-step' submission process.

1—Peer review: Authors first contact peer reviewers (two for journal papers; three for mycobiota/fungae) before sending them formatted text & illustration files and the appropriate 2022 Mycotaxon journal or mycota reviewer comment form. Experts return revisions & comments to both the *Editor-in-Chief* <editor@mycotaxon.com> and authors. All co-authors must correct and *proof-read* their files before submitting them to the *Nomenclature Editor*.

2—Nomenclatural review: Authors email all **error-free** text & illustration files to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz>. Place **first author surname** + **genus** + 'Mycotaxon' on the subject line, and (required) attach a completed submission form. The Nomenclature Editor will (i) immediately assign the accession number and (ii) after a few weeks return his notes and suggested revisions to the author(s) and *Editor-in-Chief*.

3—Final submission: All coauthors thoroughly revise and proof-read files to prepare error-free text and images ready for immediate publication. Poorly formatted copy will be rejected or returned for revision. E-mail the final manuscript to the *Editor-in-Chief* <editor@mycotaxon.com>, adding the **accession number** to the message and **all** files, which include a **(i)** revised 2022 submission form, all **(ii)** text files and **(iii)** jpg images, and **(iv)** FN, IF, or MB identifier verifications for each new name or typification. The *Editor-in-Chief* acknowledges submissions within two weeks of final submission but requests authors to wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & publication: The *Editor-in-Chief* conducts a final grammatical and scientific review and returns her editorial revisions to all expert reviewers and coauthors for final author approval. Author-approved files are placed in the publication queue.

The PDF proof and bibliographic & nomenclatural index entries are sent to all coauthors for final inspection. After PDF processing, the *Editor-in-Chief* corrects only PDF editorial/conversion and index entry errors; corrections of all other errors are listed in the Errata of a subsequent issue for no charge. Authors will pay fees for mycobiota uploads, optional open access, and correction of major author errors to the *Business Manager* <subscriptions@mycotaxon.com> at this time.

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Mycotaxon online— www.ingentaconnect.com/content/mtax/mt

The Mycotaxon journal publishes four quarterly issues per year. Both open access and subscription articles are offered.

From the Editor-in-Chief

Three mycological giants have this way passed—Our remembrance section covers the lives of three men who made outstanding contributions both to mycology and to this journal. During 2021 we lost on June 14 Jack David Rogers (age 83), beloved dean of *Xylariaceae* and 1990–1998 Mycotaxon Editorial Advisory Board member; on October 12 Kálmán Géza Vánky (age 91), the world's leading authority on the smut fungi (*Ustilaginomycotina*) who published 56 significant papers in Mycotaxon; and on October 13 Grégoire Laurent Hennebert (age 92), who with Dick Korf founded Mycotaxon in 1974 and served as Book Review Editor (1974–1991) and French Language Editor (1974–2006). Assembling the photographs and researching the background to add to personal reminiscences extended our already seriously late October–December 2021 issue, but we could not permit their histories to go uncelebrated or postponed.

Deleting those pesky prime symbols—For several years, our authors and your editors have struggled over properly formatted latitude/longitude coordinates. The process has been particularly onerous on the editorial side because primes visible in MSWord Times/Times New Roman transform into peculiar, seemingly unrelated symbols in the Editor-in-Chief's Adobe InDesign® program. Until recently, global replacements could sometimes handle corrections in the program, but an unfortunate recent Adobe® update now transforms all single/double prime symbols as empty pink boxes, requiring tedious individual replacement of each symbol one by one—no doubt portending Adobe's intended removal of the 'symbols' fonts, certain to make future formatting even more dire.

Therefore, Mycotaxon issues a new requirement for lat/long coordinates that should reduce everyone's agony by eliminating the old degree/minute/second presentation style. Henceforth:

(1) Authors should present their data as degrees with fractions rounded off to four decimal places. [Note: 1° = <111 km, and 0.0001° = <11 m, so any additional decimal places represent spurious accuracy. We shall definitely accept coordinates rounded to fewer than four decimal places.]

(2) No space should be inserted between the data and its cardinal letter [N, E, S, W].

(3) Place one space but no punctuation between the latitude and longitude components of a single set of coordinates. Example:

Old and/or incorrect: 38°10′46″N, 13°15′40″E

New: 38.1794°N 13.2611°E.

The 2021 October–December Mycotaxon offers 18 contributions by 60 authors (from 9 countries) revised by 35 expert reviewers and the editors.

The new taxa section proposes two new genera (*Flavodontia* from China & *Pseudodeightoniella* from India) and eleven species new to science representing *Architrypethelium* from Mexico; *Aspicilia, Flavodontia, Lepra,* and *Pertusaria* from China; and *Clavaria* and *Pseudodeightoniella* from India.

Validation presents a single paper validating five *Peronospora* species. Typifications, also comprising one paper (but a long one), sets forth an entertainingly convincing history that establishes three Fries, Bolton, and Berkeley *Agaricus* names as synonyms of the lovely and nomenclaturally controversial *Lichenomphalia umbellifera*.

New ranges/hosts reports range extensions for [ascomycetes] *Ascochyta, Mycosphaerella, Phyllosticta,* and *Rhabdospora* in Turkey and *Podosphaera* in China; [basidiomycetes] *Cortinarius* in Turkey; [lichens] *Astrochapsa* and *Chapsa* in China; and [myxomycetes] *Cribraria* and *Physarum* in Turkey.

Our issue concludes with the announcement of two new mycobiota for the Mycotaxon website that cover macrofungi in Mexico City and *Agaricus* species in Pakistan.

Mycotaxon 136(4) also provides identification keys to *Pertusaria* and *Clavaria* species. Papers providing conclusions supported by sequence analyses cover the new *Aspicilia, Clavaria, Flavodontia,* and *Lamprospora* species and the new records for *Cortinarius* in Turkey and *Podosphaera* in China.

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)
6 February 2022

In celebration

Fig. 1. Professor Hennebert at age 50 in 1979 on the 'new' campus in Louvain-la-Neuve.

Mycotaxon bids an affectionate farewell to our last co-founder: It is with profound sadness we note the loss of Grégoire Laurent Hennebert on 13 October 2021 at the age of 92. We shall miss this gentle soul, who was the consummate mycologist's mycologist, master of both fungal taxonomy and nomenclature, tireless collector, outstanding fungal ambassador, and brilliant scholar.

Gregoire's early work was sparked by Prof. Victor Estienne, who commented that scientists recognized several different *Botrytis* species on the onion (*Allium cepa*), but "What are they, exactly? Are they not all *Botrytis cinerea*?" His advisor recommended that the young Hennebert research host specificity by comparing the different 'taxa through cross-inoculations in host plants." A good suggestion, perhaps, except that these "cross-inoculations failed."

A conversation with Niels Buchwald (1949: Studies of *Sclerotiniaceae*) turned Grégoire's attention toward a different direction. "The matter is primarily taxonomical. There are many names of *Botrytis* species in the literature. Many are not *Botrytis,* some are, and among these, a number are host specific, others are not. Differentiation of the species is first of all morphological. You should compare fresh collections morphologically, from nature and in culture. You should look for the perfect stage in nature and find out the correct name to apply." That comment in 1957 "launched me into the taxonomy and the nomenclature of the fungi." Grégoire became an exceedingly meticulous collector, who knew the importance of thoroughly screening a potential type locality and delivering a reliable type specimen: "Later wanting to provide sufficient type material for herbarium deposit [of *Arachnophora fagicola*] in view of publication, I had to examine

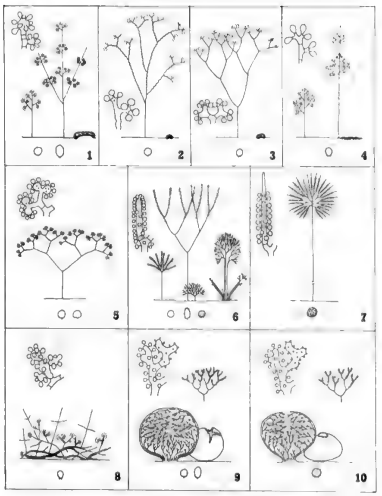


Fig. 25. Diagrammatic illustrations of coniophomata of 1. *Botrytis*; 2. *Streptobotrys*; 3. *Amphobotrys*; 4. *Verrucobotrys*; 5. *Dichobotrys*; 6. *Chromelosporium*; 7. *Pulchromyces*; 8. *Phymatotrichopsis*; 9. *Ostracoderma*; 10. *Glischroderma*.

Fig. 2. The many faces of *Botrytis* sensu lato.

eight thousand beech cupules from the same locality to finally have eighteen minute colonies of that new fungus to serve as a type."

Of the 380 *Botrytis* names in the literature, many were already synonymized while others were described through short Latin descriptions frequently lacking illustrations. Grégoire turned to nature: "exploring woods, swamps, ponds, fields, vineyards, orchards and vegetable plots, flower gardens, agricultural and forest soils, even caves ... collecting specimens and [isolating] *Botrytis* strains in pure culture.... [Most] cultures were conidial and sclerotial. I was disturbed finding in some of them small globose conidia—like *Penicillium* conidia—even in single *Botrytis* conidium cultures. I could not obtain their germination and concluded that they were spermatia...."

Realizing that these *Botrytis* forms were asexual and 'imperfect,' Hennebert returned to the field to collect apothecia on sclerotia together with *Botrytis* conidiophores (representing *Botryotinia globosa*, *B. ficariarum,* and *B. calthae*) under the host plants *Allium ursinum*, *Ficaria verna,* and *Caltha palustris.* The apothecia, produced by sexual ascospores, represented the sexual ('perfect') states of the asexual *Botrytis* stage."

The spontaneous development of apothecia in a *Botrytis porri* pure culture (isolated from *Allium porrum*) raised the problem of nomenclature: "To each state of the fungi, imperfect state and perfect state, a distinct Latin binomial

name was given. This is heritage of the past when mycologists considered each reproductive form a distinct species.... Several names for one fungus species appeared contrary to Linné's principle and that of the International Code of Botanical Nomenclature, one taxon—one name. In such cases the Code prescribes the predominance of the name of the sexual form over the other names [but] tolerates ... the use of the other names. That peculiarity of the nomenclature of the pleomorphic fungi struck me....

"Soon I had hundreds of *Botrytis* isolates in pure culture beside isolates of many other fungi, an embryo of a fungus culture collection or MYCOTHÈQUE.... 'But why bring nature in small tubes?' questioned a relative of mine, long ago. Why a fungus culture collection? Why a mycothèque?' [I replied] 'to help elaborate a more natural taxonomy of the fungi, through demonstration and comparison in pure culture of their morphology and pleomorphy, and correlatively to resolve nomenclatural problems that pleomorphy may cause.' TAXONOMY and NOMENCLATURE were, to me, the prime reasons for building a mycothèque."

In 1995 Grégoire summarized, "Taxonomy and nomenclature are at the base of all activities of man who observes, thinks, and communicates. Observation leads to thought, thought to concepts. Taxonomy is the result of observation and thought. Nomenclature results from thought and concepts. Taxonomy and nomenclature [are] at the base of all common knowledge.... Observation of the diversity of things induces comparison and distinction and leads to elaboration of concepts and to formation of words. If a concept is a category, the word is a noun; if it is an attribute, the word is an epithet. Categories are genera, epithets refer to species. That is taxonomy. Nouns are generic names, nouns plus epithets are species names. That is nomenclature. Common knowledge is made of taxonomy and nomenclature."

During 1962–65 Grégoire was appointed UCL Plant Pathology Teaching Associate and charged with developing the Fungus Culture Collection

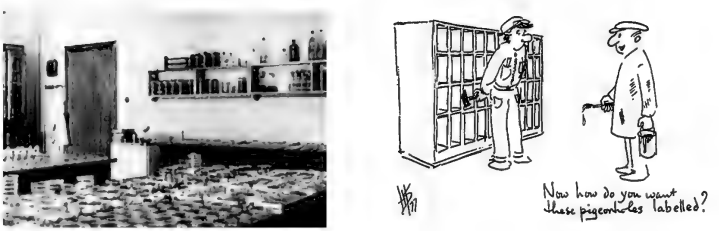


FIG. 3. LEFT: Grégoire's 'embryo of a mycothèque' in 1965 at the Catholic University of Louvain in Heverlee-Leuven. RIGHT: Taxonomy vs nomenclature in the 'olden' days.

Fig. 4. The 1894–2021 MUCL time-line

at the Faculty of Agriculture, Heverlee-Leuven (Fig. 3); this preceded his eventual development of Mycothèque de l'Université Catholique de Louvain [MUCL]; during his 26-year tenure as supervisor of his beloved mycothèque, he guided the expansion of the 300-strain culture collection from its modest

beginnings as the Mycothèque Biourge to 35,000 fungal strains and (by 2010) the curation of 51,000 dried specimens (Fig. 4).

Courtesy of Gertrude Hennebert

Fig. 5. Young Grégoire at the lab bench at the Catholic University of Louvain (date unknown).

Grégoire matriculated at the University of Louvain (UCL) in 1947, receiving his bachelor's in philosophy as Engineer in Tropical Agriculture and becoming a Superior Scientific Education Graduate Associate in African Sciences. His four years researching Plant Pathology at UCL were funded by the Fonds National de la Recherche Scientifique.

After successfully defending his PhD thesis on *Botrytis* and the *Sclerotiniaceae* in 1960, Grégoire was awarded a 2-year postdoctoral Fellowship with Dr. Stan Hughes of the Plant Research Institute in Ottawa, Canada, a time that he recalled with great fondness, and which re-introduced him to the joys of field work (Fig. 6). "The first step of any mycological study is the observation of the fungi in the field. To teach this basic requirement, Dr Stanley J. Hughes, the first day after my arrival in Canada for a two-year postdoctoral stay (1960-62), took me to the forest, in Gatineau Park, to collect microfungi, field shoes on feet, knife and basket in hands."

"Professor Richard P. Korf, who I visited at Cornell University in 1961 for the first time of many, was doing the same with his students: 'no mycology in

Fig. 6. The importance of fieldwork. left: Prof. Stanley Hughes collecting in Gatineau Park, near Ottawa in 1960. right: Prof. Richard Korf in 1961 sorting fungal specimens during a field trip near Ithaca, New York.

class or laboratory before a discovery of the fungi in the field.' The bonnet of the car could serve as a bench to sort the collections. But take care: some fresh polypores, like *Ganoderma applanatum,* exude drops of enzymes so active that within one hour's time you may have to ... repaint the bonnet."

Grégoire became Professor in 1971 and registered MUCL with the WFCC and IAPT in 1972. During 1964–75, he was a regular scientific collaborator of the Centraalbureau voor Schimmelcultures, visiting Baarn every two weeks. In 1975, after being "obliged to move laboratory, herbarium, the MUCL culture collection, and furniture 30 km south of Brussels onto the bare new campus named "Louvain-la-Neuve," he was elected president of the Faculty of Microbiology and Bio-industries, a position he held for five years.

Throughout these decades Grégoire served as a visiting lecturer/professor throughout North America, Africa, and Europe at Cornell University (Ithaca, New York), the University Lovanium in Kinshasa (Congo; 1967), Québec's Laval University (1970), Prague's Czechoslovakian Academy of Sciences (1970), South Africa's Potchefstroom University (1981), Bujumbura's University of Burundi (1982–90), Slovenia's Boris Kidric Institute of Chemistry (Ljubljana), and Morocco's Institut Agronomique et Vétérinaire d'Agadir (1986). During this period was also invited by Prof. A.M. Cotes-Pradohe to evaluate the CORPOICA Germplasm Bank in Bogota, Colombia.

Grégoire's African tropical research revealed some problems associated with following a strictly classical approach when faced with largely unexplored fungal diversity. These issues formed the basis for a spirited discussion among the 150 registrants of the 1994 MUCL Centenary Symposium (Fig. 7). "A priority and urgent duty is to describe and make the inventory of this mycoflora,

Mid-l&rr: courtesy of Gertrude Hennebert

Fig. 7. The 1894–1994 MUCL centenary symposium—a time for science & reunion. top: Official conference photo, 29 June 1994. mid-left: In 1974 C.V. Subramanian (hiding two steps above Grégoire in the top photo and who first visited MUCL in 1965) receives a handshake from Grégoire in India congratulating him on his 50th birthday. mid-right: Grégoire & Stan Hughes at the microscope during Stan's 1973 visit to MUCL. bottom left: Stan Hughes and Dick Korf at the 1994 symposium. bottom right: Lidwina Hennebert (left, next to Grégoire's empty chair) and Dick & Kumi Korf (right) at the symposium dinner at the Abbey Hôtel of Villers-la-Ville.

using microscope and culture in situ, for which well-trained young mycologists are needed. And on that basis, elaboration of monographs should provide the necessary tools to further investigations." The symposium attendees agreed that tropical fungi differ from those of the temperate regions and that morpho-anatomical taxonomy had to be complemented by molecular taxonomy.

"Good phylogeny based on molecular data may demonstrate relationships that might lead one to amend the system of the fungi at the highest ranks." They agreed that a new training profile was needed for tropical and temperate regions covering ... "different disciplines, including computer science, cladistics, molecular biology, [and] ecophysiology without neglecting ... traditional but unavoidable and basic methodologies of fungal taxonomy—collecting, microscopying, drawing, isolating fungi into pure culture, studying type material, interpreting past literature, writing descriptions, constructing keys, writing monographs, building expert systems of identification and managing herbaria and culture collections. These are the first acts for a mycologist in tropical and unexplored areas of the world."

Founding Mycotaxon: In 1960 at the beginning of his post-doc with Dr. Hughes in Ottawa, Grégoire met Dr. Richard P. Korf for the first time. "Dick invited Lidwina and me to his home along the Lake in Ithaca in the summer 1961. At his door, when we arrived, we found the message 'Welcome, come in, the house is yours, we come very soon, Dick.' Surprising!" During September 1969 (at the Kananaskis Conference on pleomorphy) "we discussed [day and night] the nomenclature of the pleomorphic fungi [and] about my distinction between botanical and anatomical nomenclature. I was greatly honored when, as Fulbright Scholar in 1972–73, he chose to stay with us at the University of Louvain." (Hennebert 2018)

Dick had visited MUCL on 13 June 1966. During his 6-month-long stay in 1972–73, in addition to hosting a conference on 'A new classification of the operculate discomycetes,' he discussed with Grégoire the need for a timely mycological publication geared to taxonomy and nomenclature. "Even after searching for guarantee of the novelty, it is important to publish rapidly. As very few journals were editing manuscripts with a delay shorter than 6 months, [Korf] and I decided to edit a new journal offering only a short delay together with quality, designed to promote the taxonomy of fungi and lichens" (Hennebert & Korf 1974).

Their proposed endeavor turned out to be a life-time commitment. Since sending out its first volume in July 1974, Mycotaxon has published

Fig. 8. Hennebert & Korf at Louvain-la-Neuve making plans during Korf's 1972–73 Fulbright studies to launch a new mycological journal devoted to the taxonomy and nomenclature of fungi and lichens.

136 volumes comprising approximately 82,000 pages in its journal. In 2004, Dick, Grégoire, and the Editorial Board agreed that we remove the overly lengthy mycobiota (annotated regional species lists) from the journal to be summarized/abstracted in the journal and posting ~3500 much larger pages for free download from the Mycotaxon website. The founders and Board also approved (in 2004) moving to editorially generated copy, (in 2011) offering both online and hard copy subscriptions, and (in 2014) moving to annual volumes comprising four quarterly issues. While Grégoire and I mourned somewhat the move to online publishing (I chose black for the cover announcing the change), Dick welcomed it as a positive "green" solution.

Dick served as Managing Editor & English Language Editor (1974–91), Assistant to the Editor-in-Chief (1998–2001), Business Manager (1991–2006), and Treasurer until shortly before his death in 2016. Grégoire served 17 years as Book Review Editor (1974–91) and 32 years as French Language Editor (1974–2006). His many years of service to the journal continued until the end: he published in Mycotaxon his last three papers on *Glischroderma*

(Hennebert 2018), the possible congeneric relationship between *Pachyphlodes* and *Chromelosporium* (Hennebert & Decock 2020), and a reevaluation of *Chromelosporium* and description of two new genera *Chromelosporiopsis* & *Geohypha* (Hennebert 2020).

Enter anamorph, teleomorph, and holomorph: In his last lecture, Grégoire noted that the diverse conditions in culture permit 'the fungus to reveal itself in more facets than expected," thereby helping demonstrate the variability and mutability of a fungus.... Only through single spore culture, [could it] be demonstrated that spermatia belong to *Botrytis cinerea*." Linnaeus (1753), who based his taxonomy on sexual reproductive structures, classified plant taxonomists according to their basic principles of classification, considering himself a 'sexualist;' with fungal sexuality and pleomorphism unknown in the 18th century, any distinct reproductive form was considered a distinct species and named (leading inevitably to a proliferation of names for a single species). Grégoire's early study of conidiogenesis in culture had reduced the taxonomy of *Botrytis* to some 36 species but also underscored the confusion surrounding life stage nomenclature.

Tulasne, who in 1851 called pleomorphy the coexistence of several forms of reproduction in fungi, demonstrated the organic connection between ascosporic fungi and conidial fungi as the 'perfect [or sexual] state' ... and the 'imperfect state or states' of the same species, as several conidial forms of reproduction might exist in the same 'perfect' species. Eventually Fuckel classified fungi as belonging to the Fungi Perfecti and the Fungi Imperfecti. Through his 1867 Lois de la Nomenclature Botanique Art. 15, De Candolle "reinforced the principle 'one taxon—one name,' while Saccardo (1904) recommended a dual nomenclature for pleomorphic fungi in Fungi Perfecti and Fungi Imperfecti, thereby supporting usage of 'imperfect' names beside the 'perfect' name. The 1910 Brussels Botanical Congress integrated Tulasne and Saccardo's positions, recognizing for ascomycetes and basidiomycetes the predominance of the name of the perfect state over the names of their imperfect states, thereby tolerating the use of the existing names of imperfect states to be classified in 'form-genera' and assigning them 'only a temporary value.'

In 1966 the Edinburgh Code established Art. 59, intended to separate the imperfect and perfect nomenclatures while preserving the stability of the names of perfect species. Korf (1982) noted that in practice, however, Art. 59 was "undoubtedly one of the thorniest articles of the Code for mycologists to apply," and Hawksworth (1984) deemed it "extraordinarily complicated, so that

in some instances, up to three separate conclusions could be drawn regarding names to be used."

At the 1969 Kananaskis Conference on Taxonomy of the Fungi Imperfecti, Grégoire presented a paper on the fundamentals of pleomorphic and pleoanamorphic fungi, in which he (supported by Korf) formulated the concepts of 'phase' vs 'state', 'form', 'whole fungus' vs 'perfect' & 'imperfect states', 'botanical taxon' vs 'form-taxon', and 'botanical' vs 'anatomical' nomenclature in order to define adequately the divergent options applied by fungal taxonomists in naming pleomorphic fungi (Hennebert 1971).

In 1969, Grégoire became a member of the International Association of Plant Taxonomy's Special Committee for the Nomenclature of Fungi and Lichens (IAPT-N), which he served until 1986, and was one of 12 members in Subcommittee A at the First International Mycological Congress in Exeter, September 1971.

He recalled that that in 1977, "just playing with words in a conversation with Dr Luella Weresub [the formidable chair of Subcommittee A whom he knew from his 1960-62 studies in Ottawa], I proposed some less 'imperfect' terms than the anthropomorphic 'perfect' and 'imperfect,' hopefully terms without value judgements ... to designate the anatomical parts of a fungus deserving a name.... We published the terms 'anamorph,' 'teleomorph,' and 'holomorph' to differentiate any fungal 'morph' deserving a name (Hennebert & Weresub 1977) .... The term 'anamorph' was proposed for any asexual state of the [asexual phase], the term 'teleomorph' for the unique sexual state of the

https://www.facebook.com/umanitobasci/

Fig. 9. Luella Weresub was the first woman faculty member to be hired in the Department of Botany of the University of Manitoba in 1952, moving to the mycology unit of the Department of Agriculture in Ottawa in 1957, where she worked until her death in 1979. Dr. Weresub, an expert in corticioid fungi and sclerotium-producing basidiomycetes, became a world authority in the botanical nomenclature of fungi and particularly influential member of the IAPT Nomenclature Committee for fungi and lichens as Chair of the Subcommittee on Article 59.

fungus, and the term 'holomorph' for the 'whole fungus' (which encompassed all unknown 'morphs')."

This proposed modification of Art. 59 was recommended in 1977 by the Second International Mycological Congress in Tampa and adopted by the Sydney Code (Stafleu 1981). While simplifying the previous rule, the language reinforced segregation of ascomycete and basidiomycete anamorphic nomenclature from teleomorphic (holomorphic) nomenclature based on their 'anatomical' typifications, clearly declaring "anamorphic names unpriorable in holomorphic nomenclature in case the anamorphic fungi were ever found to be sexual. It was the most conservative option, far from the true botanical nomenclature requiring the suppression of Art. 59, [which] I considered the final solution." The new Art. 59 did offer two advantages: it solved "a serious nomenclatural knot by a clear practical line" and stimulated reconsideration of the basic principles of fungal nomenclature.

"For plant pathologists, anamorphic names of plant pathogens often serve to designate plant diseases. Similarly, in medical mycology, names of mycoses commonly derive from the anamorphic name of the causal agent. Both practices are regrettable since they link disease names to a not infrequently changing reference basis. ... The true reason [for] maintaining Art. 59 was the fear of the major disturbance that its suppression and a return to unrestricted typification and absolute priority of names would cause ....

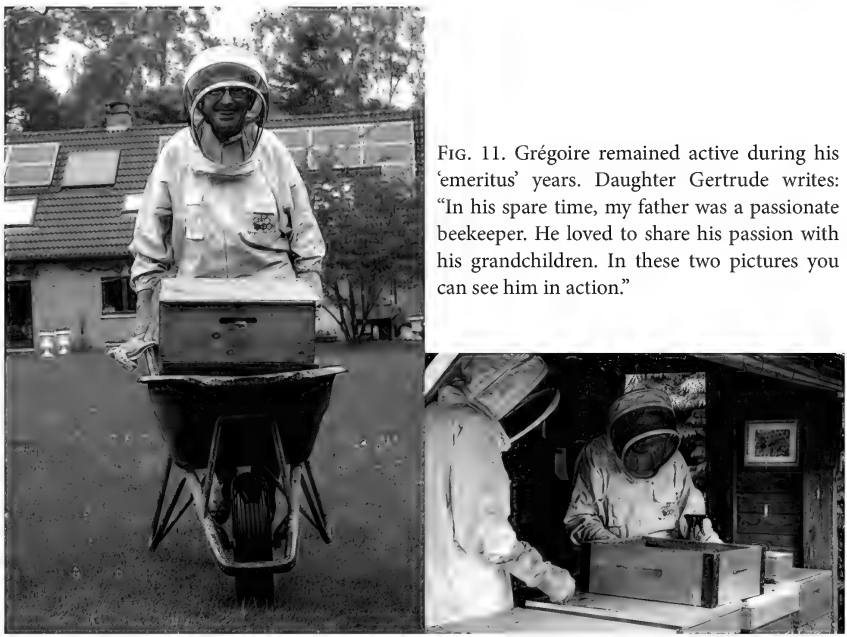
"Obviously, good sense must prevail. The fundamental aim of naming living beings is indeed to make possible their recognition, inventory, and classification, by giving each of them a single name and not a multiplicity of names (Hennebert 1991). I therefore prefer giving one name only to pleoanamorphic fungi. So I proceeded in naming and describing *Botrytis*, *Chalaropsis, Wardomyces, Mammaria, Humicola* species, using eventually a cross-reference generic denotation for what I considered the 'secondary' conidiogenesis."

In his memoriam to Grégoire in IMA Fungus, David Hawksworth observed that it was "gratifying to see how [Grégoire] came to openly accept the demise of the use of the '-morph' terms when the separate naming of morphs of pleomorphic fungi was abandoned in 2011. This is evidenced in his last publication ... where he revisited and revised some of his previous taxonomic and nomenclatural conclusions (Hawksworth 2021).

Grégoire Laurent Hennebert was born on 20 June 1929 to Dr. Raymond Hennebert and Marie (Wallez) in Mons, Belgium (Fig. 10). In 1960 he married Lidwina Baert, with whom he shared a long and happy marriage

http://www.paulcuvelier.Org/?p=9053

Fig. 10. The Dr. Hennebert family in Mons, Belgium, 1944. left to right: Grégoire (age 15), Alexis, Dr. Raymond Hennebert (father), Paul, Julie, Marie Wallez Hennebert (mother), Colette.



Courtesy of Gertrude Hennebert

Fig. 11. Grégoire remained active during his 'emeritus' years. Daughter Gertrude writes: "In his spare time, my father was a passionate beekeeper. He loved to share his passion with his grandchildren. In these two pictures you can see him in action."

until her death in 2009, and was the proud father of four—Gertrude, Mechtilde, and Imelda Hennebert and Khan Nuhr—and grandfather to twelve, many of whom he taught about the joys of beekeeping (Fig. 12). Grégoire exercised regularly and was in unusually good health, expecting to reach 100 after his successful heart surgery in 2021. Unfortunately, after falling in his garden and breaking a vertebra in his back, he was hospitalized and rapidly declined, slipping away five weeks later on 13 October 2021. His daughter Gertrude wrote that Grégoire would "never have thought that he would die as the consequence of a fall."

Honored by the genus *Hennebertia* and seven *hennebertii* species epithets (in *Acremonium, Chaetopsis, Cylindrotrichum, Gliocladiopis, Niesslia, Penicillium,* and *Raffaelea*), Grégoire himself named 18 genera and 114 species. He guided 55 research studies in applied mycology (26 at the University of Burundi) and published alone or with colleagues 156 scientific papers (not including 13 culture papers). He also edited the 100 years of the Fungus collection MUCL 1964-1994 symposium proceedings, two books on Les Mérules des Maisons, and the Directory of African Mycology and the Aspects of African Mycology from the first Regional Conference on Mycology in Africa.

Grégoire remained mycologically active after his retirement in 1995, although he did not have particularly fond memories of his 'emeritus' status. In 2017, he explained that the long delay in preparing his paper on a *Glischroderma* collected by Dick in 1994 arose from problems caused by a misunderstanding over his taking the books reviewed for Mycotaxon (contractually his) and the expectation that he administer the lab without pay for a year, after which he was denied lab access. Not until he discovered Dick's potential type in Geneva, did he remember his unfinished paper. Although fairly certain that the specimen represented a second species, he described it as *Glischroderma* aff. *cinctum*. "Fresh collections and DNA analyses might solve the question better than I can do. I think I shall just raise the question. I shall not be 'waiting for that elusive muse, perfection,' although it is a temptation...."

On discovering a nonsensical but rather major error in the final proof of his 2020 paper with Cony Decock that none of us had noticed in previous versions, Grégoire became understandably distraught. My prompt repair elicited this grateful note, "Dear Lorelei, Many thanks for the exceptional correction, as a New Year gift. It is now perfect. I am happy and makes me better in insomnia and allows me to go to sleep again."

Fig. 12. Post 'retirement' life. left: Peter Austwick, Grégoire, and Stan Hughes relaxing during the 1996 Centennial Meeting of the British Mycological Society in Sheffield, England. right: Grégoire and Walter Gams discuss Article 59 and the launching of MycoBank at the Centenary of the Centraalbureau voor Schimmelcultures in Amsterdam in 2004.

His 2018 *Glischroderma* paper led him to reexamine his *Chromelosporium* archives and the monograph he began with Stan Hughes in 1960-62 while in Ottawa but had never completed despite encouragement from both Stan and Dick. Feeling he owed it both departed friends that he complete the work, Grégoire also felt it necessary to sequence as many specimens as possible to sort genera and nomenclature correctly. "With the precious help of Rosanne Healy and MUCL, I progress in the revision of the genus, including nine and possibly more species. But it progresses slowly with so many other things needing to be done.... I am sorry to inform you that on 21 December [2017] I got a heavy car accident stopping against a tree. I have nothing broken but the chest smashed in by the belt, making the holidays painful. I wish you a happy and healthful New Year."

Grégoire prepared his final paper under pandemic conditions. Replying to my concern about the lock-downs and huge numbers of Covid-19 cases sweeping his country, he noted, "Yes Belgium is in bad health situation by lack of foresight. From begin of March, the virology laboratories were all lacking chemicals for testing, while the virus was already present. And the stay-home rule was decided only on March 15 [2020]. I stay home and have visit of my daughter only when needed.... You should be safe in your Nature environment. I have only a piece of ground of 30 × 50 m with my house, a piscine, and some green (now absolutely brown by the drought) but sufficient to be far enough from neighbours."

I never had the pleasure of meeting Grégoire in person but came to greatly enjoy our correspondence. Meticulous as he was, Grégoire worked his reviewers (Kathy Hodges, Roseanne Healy, Keith Seifert, David Hawksworth)

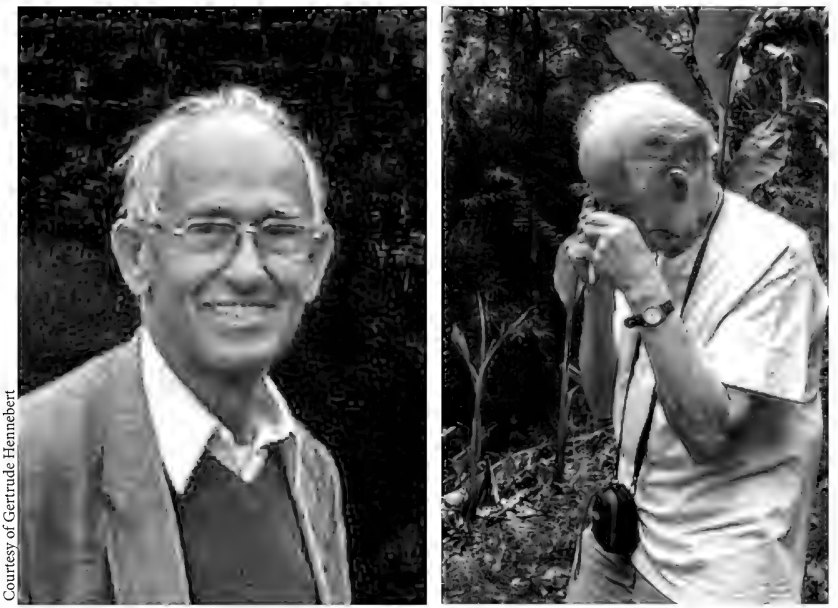


Fig. 13. Grégoire Hennebert turns 80 (2009).

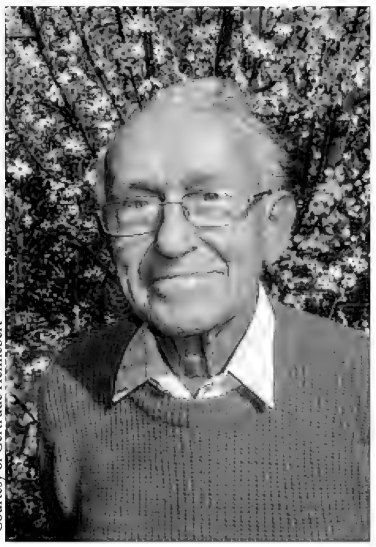
and editors exceedingly hard, yet received all critiques graciously, expressing his gratitude frequently. "Dear Lorelei, I just received my last paper reviewed by Keith Seifert. He proposed many amendments, a lot of work for me." Extremely worried that his 'last' paper would not get published, he greatly appreciated that David and Keith came to his aid. Shaun and I, who spent well over 100 hours emailing, revising, and adjusting, were rewarded by his immense relief when it was released in Mycotaxon 135(3). On 9 October 2020 he wrote: "I am very pleased with the paper, and I thank both Shaun and you so much for the improvement of the manuscript, the time you putted in it, and the priority you gave it by agreeing to publish it in the year 2020. With loves, Grégoire" This was followed on 30 October 2020 by, "Dear Lorelei, dear Shaun, I just received Mycotaxon 135(3) via Lulu and found my 'last paper' in full on 54 pages and a kind comment by yourself in the introduction of the volume. I really want to express all my thanks to Shaun and to you for the edition of my paper in Mycotaxon 2020. Now, although there are some other unachieved projects (which are for others), I conclude by this paper my work in Mycology with real satisfaction. With many thanks, Grégoire."

Grégoire was a warm and kind correspondent, frequently sharing advice gained from the successful cancer treatment and preventative measures

(immunotherapy, shiitake, *Grifola frondosa, Cordyceps militaris*) used after Lidwina's bout with breast cancer. A believer in healing touch therapy, he also used willow herb (*Epilobium parviflorum*) for his own prostate cancer and hawthorn berry and heather teas to help him heal after his 2010 and 2012 heart attacks. Beyond doubt, his positive attitude kept him healthy for so long, "Absolutely YES, Life is good and beautiful. I enjoy it fully."

Gregoire was declared Professor Emeritus after delivering his 'last lecture' on 5 December 1995, yet he published his last papers in the journal he co-founded almost a quarter century later. We are grateful that he and Dick established Mycotaxon 48 years ago and will continue to miss our two mycological giants, whose vision was always for the future.

—Lorelei Norvell



Courtesy of Gertrude Hennebert

Fig. 14. Grégoire Hennebert in his garden, smiling for his 90th birthday photo.

Acknowledgments

We greatly appreciate the many photos and information generously provided by Grégoire's daughter, Gertrude. Unless otherwise noted, quoted text was taken from Grégoire's final 1995 lecture, private autobiographical notes, and Mycotaxon editorial correspondence. All unattributed photographs were generated from computer screen shots of illustrations in the PDF version of The 100 years of the fungus Collection MUCL 1894–1994 (Hennebert 2010), covering both the proceedings of the symposium attended by 150 registrants on 29 June 1994 at the Catholic University at Louvain-la-Neuve and Grégoire's complete final lecture, delivered on 5 December 1995 prior to his becoming Professor Emeritus.

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In remembrance— Jack Rogers (1937–2021)

From Ammirati & Glawe (2008)

Fig. 1. Professor Jack D. Rogers at 80 standing beside the Department of Pathology display case at Washington State University in Pullman.

Mycotaxon mourns the loss of a second mycological giant and friend, the longtime Washington State University professor and internationally renowned mycologist famed for his "booming voice, distinctive West Virginia accent, disarming and endearing sense of humor, enthusiasm for the outdoors, and genuine care for students and colleagues." Jack David Rogers died at home in Pullman, Washington on June 14 at the age of 83. Deep condolences go out to Belle, his wife of 58 years, twin daughters Rebecca Ann (Hines) and Barbara Lee (Cooper), and family. This brusque but lovable man will also be greatly missed by his international network of colleagues, friends, and former students.

Professor '*Xylariaceae*' was born 3 September 1937 in Point Pleasant, West Virginia, to schoolteachers Jack Rogers (Youkobis Uzskuriatis) and Thelma (Coon) Rogers. Young Jack graduated from Point Pleasant High School in 1955, earned his BS from Davis & Elkins College (WV), marrying fellow student Belle Clay Spencer in June 1958, his junior year. After obtaining his masters in Forest Management from Duke, he earned his PhD in 1963 under the supervision

of John Berbee at the University of Wisconsin-Madison for his research on *Hypoxylon pruinatum* (= *Entoleuca mammata*), a major forest pathogen of quaking aspen in the Great Lakes States.

Directly after receiving his doctorate, Jack joined the College of Agriculture faculty of Washington State University, where he was to remain for the rest of his 50-year educational career. Appointed to Assistant Professor in the Departments of Plant Pathology and Forestry & Range Management, he quickly advanced to the rank of Full Professor. Throughout his university tenure, he taught classes in mycology and forest pathology, frequently coordinating departmental seminar series. As part of his advanced mycology series, he developed the Ascomycetes and Fungi Imperfecti course, which he taught for 36 years, and which persuaded many students to pursue mycological careers. He helped rework the Pathology Department curriculum to offer Advanced Fungal Biology, also introducing a popular general studies course—Molds, Mildews, and Mushrooms: The Fifth Kingdom. During 1985–99, Jack served as Chair of the Department of Plant Pathology while maintaining a full teaching schedule and active research program and authoring/co-authoring 70 scientific papers. Eleven master's and 17 doctoral students earned their degrees under his guidance.

Outside of family and fishing, Jack's passion was teaching, research, and the university. Washington State reciprocated by recognizing his educational and scientific excellence through many awards: its 1967 R.M. Wade Award for Instruction; 1986 Sahlin Faculty Excellence Award for Research, Scholarship, and Arts; 2005 Library Excellence Award for Service to WSU Libraries; and 2006 WSU Eminent Faculty Award. Jack was promoted to Regents Professor in 2007 and retired from the WSU faculty in 2013 after 50 years of devoted and exemplary service.

Jack definitely had presence, even when proudly holding a steelhead (Fig. 2). Given his reputation as a humorous raconteur, he was a surprisingly formal instructor. Dr. Brenda Callan, student and fellow *Xylaria* expert, writes, "he required all of his students, including graduate students, to address him formally, as 'Dr.' Rogers. Sometime after I completed my Ph.D., he gave me permission to address him by his first name. It was a difficult transition, rather like starting to call one's own father by his first name." Brenda (as have all of us who knew Jack) remarked on his deep voice: "Who could think of Jack and not hear in their mind his voice, that booming drawl? My desk was in the herbarium, and his classroom around the corner and several doors down. I never had to peek into the classroom to see if it was time

to go in to help with the labs. He always seemed surprised when I showed up right after he'd finished lecturing!" Dr. Callan also commented on Jack's unorthodox morphological descriptions, "Jack's prose sometimes painted a vividly colourful, oddball image of the fungus he was describing. For example, in Rogers & al. (1987), he describes the stromata of *Kretzschmaria* cf. *mauritanica:* 'The surface of our material resembles a deeply cracked chocolate cookie that has been dusted with sugar.' I think that was written close to lunch time." (Callan, pers. comm.)

WSU Plant Pathology Chair Dr. Timothy Murray knew Jack for 43 years, first as a graduate student and then fellow faculty member. He told the Washington State Insider covering Jack's death that "I never worked harder in a class than when I took his class.... He really was the complete package: He was a great scholar. He won awards for his research. He was very prolific in terms of publication. He was an engaging and committed teacher. And he worked on a number of higher-level university committees. He loved all aspects of the job, and he did them well.... He was also 'a real character.' He loved to tell a good joke. And he was very vocal in terms of explaining his position. If he had an opinion and it differed from yours, you would know what his opinion was." (Janovich 2022)

Even after his 2013 retirement, Rogers continued coming to his office. Dr. Lori Carris, his former master's student, *Tilletia* expert, colleague, and now WSU Professor Emerita, noted, "It was kind of a challenge to see if I could get there before Jack.... The only time he took off consistently was Wednesday afternoon. That's when he went fishing.... He loved being out in the woods. He loved anything to do with fungi." (Janovich 2022)

Jack did not restrict himself to his own university but was very active in the Mycological Society of America (MSA), which he served as Western Councilor (1970–72), Vice President (1975–76), and President (1977–78), eventually receiving its two most prestigious awards, the Weston Award for Teaching Excellence in 1992 and Distinguished Mycologist Award in 2004. It is no surprise that fellow ascomycetologist Dick Korf enticed Jack onto Mycotaxon's first Editorial Advisory Board, which he served well for eight years (1990–98).

An international authority on xylariaceous fungi, Rogers authored and co-authored more than 230 scientific papers and two mycological books. We have tallied one family (*Graphostromataceae*), 22 genera, c. 240 new species, 35 new varieties, and c. 150 new combinations named or co-authored by Jack

during his career. In 2017 Wendt, Kuhnert & Stadler honored him with the genus *Jackrogersella.*

Rogers traveled the world for research, collecting specimens and helping curate WSU's Charles Gardner Shaw Mycological Herbarium [WSP]. The National Science Foundation funded his research for more than 30 years, which, Dr. Carris noted, "really laid the foundation for a lot of the work on *Xylariaceae* that is going on today." Jack was an especially engaging collecting companion. Aware that he had described many new *Xylaria* species, in the early 1980's at one Florida foray many participants kept bringing him specimens. Carris, a doctoral student at the University of Illinois at the time, observed, "It was like they were bringing him gifts.... Even though he already had a bagful of this fungus, he would look over each specimen very carefully and say, 'Oh, that is a beauty! I think I'll keep this one.' That speaks to who he was and why people really liked him. He made everyone feel special." (Janovich 2022)

'Mr. Xylariaceae:' Andrew Whalley, who contributed to an IMA Fungus celebration of Jack's 80th birthday, confirmed that Jack's doctoral work "triggered a keen interest, and later a passion, for *Xylariaceae.* On his appointment as Assistant Professor at the WSU faculty in 1963, with positions in the Departments of Plant Pathology and Forestry and Range Management, he continued with his studies of *Xylariaceae,* at first mainly on chromosomes in *Hypoxylon* and later researching all aspects of the family. In his remarkable and distinguished career, Jack, together with a number of his many postgraduate students, established WSU as the world centre for studies on *Xylariaceae.* He was also largely responsible for developing the Mycological Herbarium at WSU, making it a renowned world-class facility for educational and research purposes.

"Jack was President of the Mycological Society of America ... and his Presidential Address 'The *Xylariaceae:* systematic, biological, and evolutionary aspects' delivered at Tampa in 1977 during IMC2 demonstrated his clear thoughts and knowledge of the family.... If Julian Miller were alive today, he would have been delighted and impressed with A revision of the genus *Hypoxylon* by Yu-Ming Ju and Jack. Jack, Yu-Ming, and San Martin have now revised 14 genera of the family and together with other former students and colleagues published numerous papers on all aspects of *Xylariaceae.*"

"I am privileged to have known Jack since the mid-1970s, and to have visited him and his family in Pullman ... and to have received them at our home in North Wales. During his trips [to Wales] we visited the type locality

Andrew Whalley

Fig. 2. Avid Fly Fisherman Rogers in 1982 proudly displaying his 17-pound. steelhead, expertly rescued from Idaho's Clearwater River.

for *Nemania chestersii* in Anglesey, collected *Hypoxylon rutilum* in Llanbedr, and *Euepixylon udum* by Aber Falls, Gwynedd, all rare species.... Considering Pullman is hardly tropical, Jack has a broad and detailed knowledge of the tropical species owing to his impressive global network of correspondents, collaborators, and former students.... Jack has a wonderful sense of humour and, together with his wife Belle, they have endeared themselves to all who know them. He enjoyed hunting and fishing whenever he had the opportunity and the 17 lb. Steelhead caught on the Clearwater River, Idaho, in November 1982 (Fig. 2) is true testimony to his success. (Whalley 2017)"

Pacific Northwest Fungi Project (PNWFP). In 2002, Co-Directors Dr. Joe Ammirati (University of Washington) and Dr. Dean Glawe (WSU Rogers doctoral student and colleague) established a consortium of mycologists and natural history enthusiasts cooperating to develop a comprehensive fungal inventory of the Pacific Northwest (Alaska, British Columbia, Idaho, Montana, Oregon, and Washington). Its mission was to facilitate cataloguing the fungi by developing educational programs, databases, coordinating research projects, and publishing an online journal initially under the name Pacific Northwest Fungi (Vols. 1–3(7); 2006–2008). Attending several meetings and forays, Jack offered sage advice when needed. Our first meeting at Pack Forest near Mt. Rainier in 2003 (Fig. 3) having convened shortly after his cataract operation, Jack described in fascinating detail his laser surgery and the new lenses slipped into place, rumbling with delight at being able to see once again in full technicolor and—for the first time—sharply without glasses.

In mid-2008, the name of the journal was elevated to North American Fungi following Jack's 80th birthday the previous year. The 267-page Festschrift in Honor of Professor Jack D. Rogers contained 17 papers by 38 authors. *Jumillera rogersii* Y.M. Ju & H.-M. Hsieh and *Camarops rogersii* Huhndorf & A.N. Mill. were among 14 taxonomic novelties; the many

Fig. 3. Attendees of the first meeting of the Pacific Northwest Fungi Project in Washington State's Pack Forest near Mt. Rainier National Park on 18 May 2003. Front (left > right): Michelle Seidl, Lee Whitford, Lorelei Norvell, Lori Carris, Jennifer Falacy; 2nd row: John Dennis, Jacoba Charles, Angela Muhlnickel, Claudia Nischwitz, Brenda Callan; 3rd row: Gary Laursen, Jack Rogers, Randy Bell, Joe Ammirati, John Hanna, Fred Rhoades; Back: Dennis Oliver, Bryce Richardson, Ben Legler, Dean Glawe.

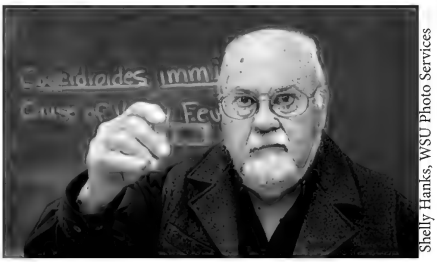
dedications touched on Jack's research philosophy (Watling & Milne: 'in the spirit of his understanding of how mycology should be conducted: to marry classical morphological and ecological methods with modern techniques'), heritage (Norvell & al.: to the indomitable West Virginian transplanted to eastern Washington's Palouse'), friendship (Hemmes & Desjardin: 'in fond memory of wonderful collecting trips together in the Hawaiian Islands'), and professorial mother-henning (Callan: 'deep appreciation to Jack Rogers for 25 years of mentorship and friendship').

Marc Stadler

Fig. 4. Jack "with the German amateur mycologists, Siegfried Woike (centre) and Hartmund Wollweber (right) in the Neandertal near Wuppertal, Germany in the summer of 2000, admiring a luxurious collection of *Daldinia concentrica*." [Stadler 2021]"

Marc Stadler first met Jack at the 1994 International Mycological Congress in Vancouver, BC. "when we discussed my work on nematicidal activities of a *Daldinia* sp. that I presented in a poster from my PhD thesis. We subsequently started a collaboration that has laid the groundwork for my own taxonomic research. I will never forget when he visited us in the Neandertal valley in 2000 and we showed him our local collection sites where we picked *Daldinia concentrica* and other European *Xylariales* (Fig. 4)."

In his 2021 IMA Fungus memoriam, Marc noted that once Jack focused on the xylariaceous fungi, he became one of the foremost experts in the field. "...In retrospect, his monographs on important *Xylariales* ... appear even more valuable. They helped [close] the gaps between classical 'macromycete' taxonomy and the molecular era via the establishment of holomorphic species concepts. Jack dedicated several decades to the meticulous studies of both old type material and freshly collected specimens in order to relate the taxonomic concepts of the nineteenth century to the 'modern' era." He and his students did outstanding work on characterizing and cultivating the world's *Xylariales,* providing "numerous valuable descriptions that now allow other researchers to establish asexual/sexual connections in this highly diverse and ecologically versatile group.... Many of the phylogenetic relationships that Jack had predicted from careful morphological studies in the 1980s and 1990s have been confirmed in our recent work on polyphasic taxonomy, including multi-locus phylogeny, chemotaxonomy, and phylogenomics." (Stadler 2021)

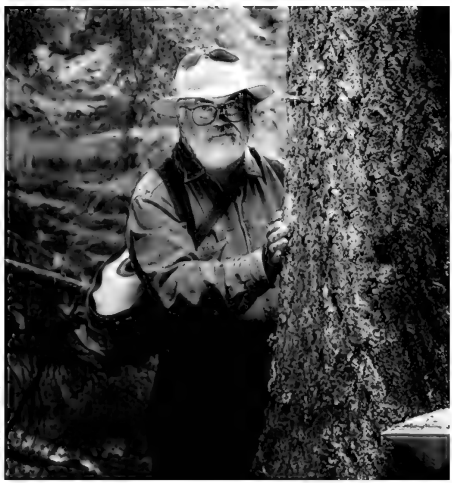


Shelly Hanks, WSU Photo Services

Fig. 5. Regents Professor Emeritus Jack D. Rogers, "international expert on fungi," holds a microscopic slide stained with *Coccidioides*-infected tissue from a dog (Washington State Insider, 4 May 2014)

In addition to Jack's myriad professional achievements, he was also an enthusiastic outdoorsman, a friend to many, and a legendary humorist. His official obituary concludes: "He particularly enjoyed hunting pheasant and quail on the breaks of the Snake River and fly fishing in rivers and lakes across the Pacific Northwest. Jack was a regular at his two coffee groups as well as the Pullman Presbyterian Church's Men's Bible Study and enjoyed visiting with his many colleagues and friends. Jack loved a good joke or humorous story and had the rare ability to remember and re-tell every entertaining anecdote he ever heard. Whenever he said 'that reminds me of a story...' we knew that whomever he was with would soon be laughing until their sides ached."

—Lorelei Norvell



Bruce Andre

Fig. 6. The Winter 2021 Washington State Insider memoriam photo captures Jack's penetrating intelligence and loving command of the forest, evoking the conviction that any friend turning around suddenly in the woods will find him standing there.

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In remembrance—
Kálmán Vánky (1930–2021)

Fig. 1. Kálmán Vánky. Undated photo of the author scanned from the dedication page of European Smut fungi (1994).

Dr. Kálmán Géza Vánky was born a Szekely-Hungarian in Székelyudvarhely (Odorheiu Secuiesc, colloquially Odorhei), Transylvania (Romania), on 15 June 1930. His website (accessed in February 2022) reflects his restless nature, citing Kálmán as the married father of three with the same German Tübingen address I visited in 2005, a Swedish email address signifying his 2014 move to that country, and joint Hungarian and Swedish citizenships. Colorful, indefatigable, enthusiastic, irrepressible, and productive are all terms that friends and colleagues use to refer to this world authority on smut fungi, who died on 12 October 2021 at the age of 91.

After earning his BS and MS in Biology from the University of Bucharest (Romania) in 1953, Kálmán spent the next four years working as a researcher for the Department of Phytopathology of Bucharest's Agricultural Research Institute. After earning his MD in 1961 from the University of Medicine and Pharmacy in Tîrgu Mureş, he practiced medicine in Odorhei and Borsec (a Romanian resort known for its mineral water springs), becoming intrigued by plant diseases. His interest in smut fungi (*Ustilaginomycotina*) having been piqued by the lectures of Prof. Traian Săvulescu, founder of the Romanian School of Phytopathology and president of the Romanian Academy, Kálmán

Fig. 2. left: Undated early photo of Kálmán at the microscope. middle: Kálmán at age 60 (1991). right: Prof. Terence Ingold and Kálmán talk during IMC IV in Regensburg (1990).

began collecting "as many different species as possible," a hobby that soon grew into his life's work.

In 1969, Kálmán moved to Gagnef, Sweden, where he continued working as a family physician, but only half-time; during 1970–86 he also worked as a "self-financed, half-time" smut fungus taxonomist, eventually securing a scholarship to Uppsala University, where he earned his PhD in Botany under the supervision of Prof. Johan Axel Nannfeldt, an expert on pathogenic rust fungi, smut fungi, and *Exobasidium*. Kálmán successfully defended his thesis on Carpathian *Ustilaginales* in 1985.

In 1986 he moved to Germany to focus exclusively on smut fungi, working as a taxonomic researcher for Prof. Franz Oberwinkler in the Department of Special Botany and Mycology at the University of Tübingen, maintaining his usual frenetic work pace: "collecting, identifying, describing, illustrating, classifying, and publishing species and genera from all over the world." By his 1995 'retirement,' he had already collected ustilaginomycetes in Europe, Africa, Asia, Australasia, and Central & North America, but his pace actually increased as he worked independently from his homes in Germany and Sweden. By his sixth collecting trip to Australia in 2017, the peripatetic Kálmán had added South America to his list, having (by his count) collected in 56 countries. [His website, however, missed Canada when he catalogued British Columbia's Victoria as part of the United States, and a few 'countries' represent unique regions rather than political entities.]

Herbarium *Ustilaginales* Vánky (HUV)—Having begun a private herbarium in Romania in 1954, Kálmán continued to add specimens from all over the world while living in Sweden and Germany. By January 2013, HUV

Fig. 3. left: Kálmán collecting in Costa Rica in 1991. right: Kálmán & Christine look on as *Tilletia* co-author Prof. N.D. Sharma inspects a specimen during their 1992 trip through India.

contained 22,050 collections, including a great number of types (holotypes, isotypes, neotypes, lectotypes, syntypes, paratypes, topotypes), apparently including 'portions of types from other collections, an issue that occasioned considerable controversy' (Hawksworth 2021).

Kálmán exchanged smut fungi for many years on a one-to-one basis and distributed exsiccata numbers 1–1350 comprising 76,500 samples from 'Vánky, *Ustilaginales* exsiccata' (1960–2010). The exsiccata contained smut fungi from all over the world, and Vánky was justly proud that it represented "the sole exsiccata of smut fungi appearing after World War II." Approximately 76,000 specimens (Nos. 1–800 with 70 fascicles, Nos. 801–1000 with 45 fascicles, and Nos. 1001-1350 with 33 fascicles) were distributed to mycological herbaria or sent to mycologists from all over the world. The exsiccata represented 615 smut fungus species (including 164 types) and 68 genera on 825 host plant taxa.

In October 2013, HUV was relocated to the Queensland Plant Pathology Herbarium (BRIP) in Brisbane, Australia, where it is now curated by Dr. Roger G. Shivas, Kálmán's co-author, fellow collector, and friend. On announcing the relocation, David Hawksworth (2013) noted, "It is gratifying that this important collection is now safeguarded for future generations, and I am sure all mycologists will wish Kálmán and his wife many relatively smut-free and more relaxing years!"

Publications—Kálmán was 26 when he published (as co-author) his first paper on the pathogenic gram-negative bacterium that caused variety of plant diseases, including 'black rot' in crucifers, *Xanthomonas campestris* (Bucur & Vánky 1956). Seven years later, he had shifted his focus to the smut fungi that he would eventually master (Vánky 1963). He named his first taxon in 1975

Fig. 4. left: Kálmán collecting on the equator in Ecuador (1993).
right: Kálmán searching for possibly smut-infected hosts in South Arica (1996).

(Vánky 1975: *Doassansia alismatis–oligococci*) and co-authored his final two taxa forty years later (Riess & al. 2015: *Talbotiomyceae, Talbotiomycetales*). Kálmán and his co-authors named a total of 13 families, 46 genera, and at least 410 new species, also publishing 19 noms. nov. and making 449 new combinations.

In total, Kálmán published ten substantial and definitive treatises on the *Ustilaginales,* the three most comprehensive of which were his 570-page European smut fungi (1994), 1458-page Smut Fungi of the World (2012), and the third 288-page edition of Illustrated Genera of Smut Fungi (2013). His critically acclaimed monographs, which supplanted Zundel's 1953 The *Ustilaginales* of the World as the ultimate world authority on smuts were all lavishly illustrated, containing "detailed nomenclators, descriptions drawings, photographs, SEM micrographs, and host lists for the world's 1650 known smut species." (Hawksworth 2021).

In addition to his books, Kálmán published 224 papers, 56 of which were published in Mycotaxon. My first encounter with this major mycological force involved his 'Taxonomic studies on *Ustilaginomycetes* 24' (Vánky 2004), which I received immediately after being appointed Editor-in-Chief. Kálmán had published in the journal since 1982 and was well-trained in our hard-copy photo-ready procedure; the manuscript was obviously in impeccable shape, leaving little for me to do but approve, paste on masthead and page numbers, send to the press, and mail the drawings and photos back to Germany after publication.

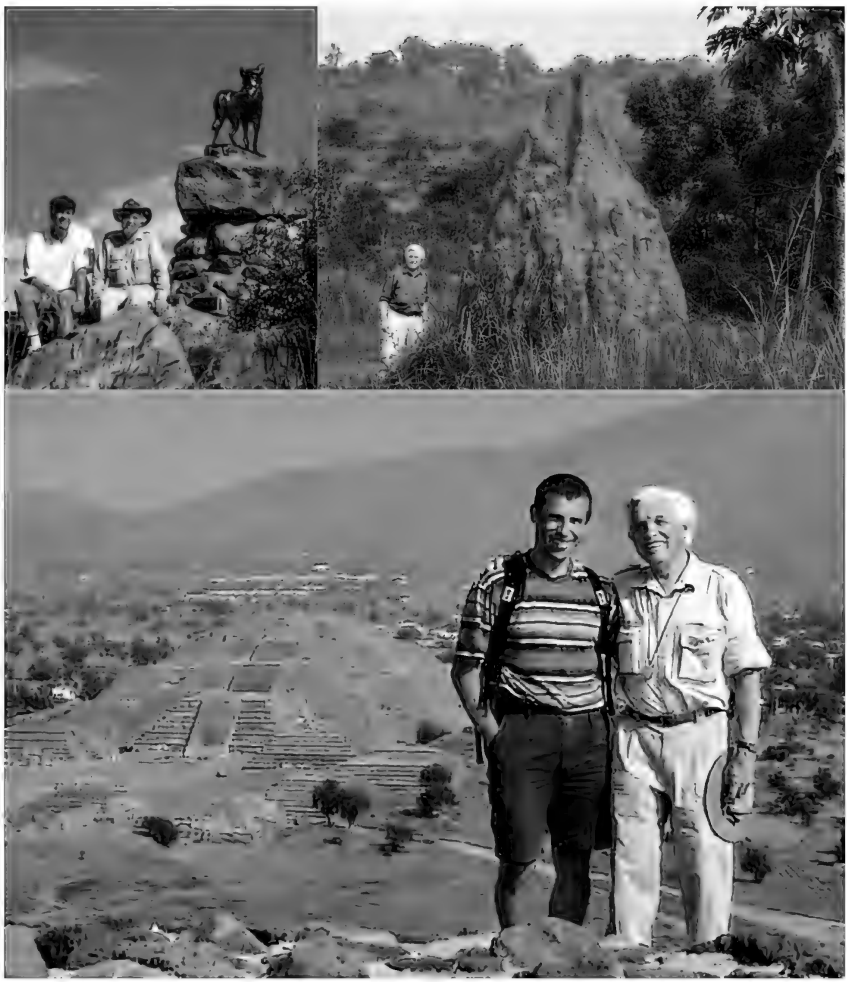

Fig. 5. left: Eric H.C. McKenzie and Kálmán collecting in New Zealand (1998). right: Kálmán standing next to a large termite mound in Uganda (2002). bottom: Son Tomas Vánky with proud father on a 2003 collecting trip through Mexico.

After the 2004 change from postal to electronic submission accompanied by style and formatting changes, followed by Shaun's addition as Nomenclature Editor in 2005, however, things became more interestingly complex, launching an era of increased editorial-author email exchange and 'artful' compromise. Kálmán's copy, prepared beautifully by wife Christine (who only later admitted that our innovations presented a real challenge), now needed numerous editorial adjustments, and the author tended to question each and every change.

Left & Top right: Lorelei Norvell

Fig. 6. left: Gracious hosts Kálmán, Christine (and Bernese Mountain Dog Tara looking for treats) lead newlyweds Lois and David Lehwalder on an evening stroll of Tübingen in 2005. top right: Christine and Kálmán cleaning the kitchen before a late-night exchange of mycological banter with visiting Mycotaxon EIC Norvell. bottom right: Undated photo of Herbarium *Ustilaginales* Vánky (HUV).

Christine's customary hard returns and page breaks wrought considerable havoc in Pagemaker® and InDesign®, necessitating considerable negotiation during a rather steep learning curve for both sides. Fortunately, we emerged victorious and friends, with my library shelves rewarded by a lovely copy of European Smut Fungi.

Learning that I would be driving with my father and brand-new stepmother through Germany to attend the 2005 International Botanical Congress in Vienna, Kálmán insisted we stop in Tübingen. July 9 found us enjoying Christine's elderberry wine, hors d'oeuvres 'sans sel' (which an eager Kálmán served too soon), and delicious dinner and then striding at dusk past lighted shop windows led by a 'wild' Hungarian, Christine, and Bernese Mountain Dog Tara along the Neckar River and over cobblestones among Tübingen students and residents. After dropping the 'newlyweds' off at the Hotel Krone, Kálmán and I discussed mycology and journals until well after midnight before I retired to my comfortable bed in the living room next to HUV. Our Tübingen stay was magical and voted unanimously the highpoint of our European trip. After our return, I received a note telling me that my contact lens solution had been left in the bathroom. "Should we send it to you? ...We prefer to keep it until you will come again to us, that time for a longer period. It was really a nice but too short stop on your way from Frankfurt to Vienna. Maybe next time it

Fig. 7. 2005. left: Fellow Roger G. Shivas and Kálmán collecting near Cairns in Queensland, Australia. right: Kálmán, Swiss rust expert Reinhard Berndt, and Christine chat during the final social banquet at the International Mycological Congress in Cairns.

will be longer? I have much to do, especially with the preparation of the world monograph. Therefore, I am ending this too-short letter. Christine and I send you our warmest regards and Tara her nicest tail-wagging."

Their travels did not always go smoothly. Recapitulating their 2006 travels through Hungary and Romania after visiting relatives and friends, Christine wrote, "Kálmán had the roots of three teeth removed and two 'new teeth' implanted. All in one session! In the evening after that, he had a proper dinner—but one that did not need too much chewing. After that exhausting experience, we wanted to spend a few days of quiet collecting in Slovenia. The first day we had pouring rain and storm, the second day Tara became seriously ill with high fever, neither wanting to get up nor eat a single bite. We hurried home to see our vet who finally found out she has Babesiosis and probably Ehrlichiosis, both transmitted by the same hungry Hungarian tick! She feels much better now, but the results of her blood tests are still very bad. Kálmán is looking forward to see the PDF file of the manuscript and we both are looking forward to seeing you in Cairns."

We did meet in Cairns during the 2005 International Mycological Congress and had an especially convivial time at the closing reception in the 'Tanks,' but Kálmán wrote about their 'rather adventurous' return, "We missed our flight in Cairns and [spent] long waiting times in several airports [before flying] Cairns–Sydney–Singapore–London–Stuttgart. Finally, tired after over 36 hours, we arrived home without our luggage, which showed up two days later in bad condition. Now, we are planning our next collecting trip to Cameroon [February/March 2006] in connection with the 18th AETFAT Congress, where I will present a talk about smut fungi of Africa."

Fig. 8. A photogenic Kálmán Vánky at age 82 (2012).

After publishing his last paper with us in 2009, Kálmán wrote that he would be finishing his mycological endeavors. "At the moment my main goal is to co-operate with the APS Press in publishing the World Monograph which could take up to one year from now. I would like also to assure that my collection will be deposited in a good herbarium and preserved under optimal conditions for coming generations.... Finally, I would like to express once more my thanks and gratitude for publishing my manuscripts in Mycotaxon, a journal which you succeeded within a few years to transform into a journal of highest scientific quality and aesthetic level. [I strongly suspect that you have in your vessels also the blood of a magician]. With all best wishes, Kálmán."

Awards and honors: Kálmán, who became a proud honorary member of the Hungarian Academy of Science in 2001, also received the Pázmány Dénes Award & Laudatio from the Kálmán László Mycological Society of Transylvania (Romania) (2012), the Arany János-Medal of the Hungarian Academy of Science (2014), and the Officer's Cross of the Hungarian Order of Merit (2020). Three species (*Anthracoidea vankyi, Orphanomyces vankyi, Uromyces vankyorum*) and three genera (*Kalmanomyza, Kalmanago,* and *Vankya*) have been named in his honor.

Kálmán's ashes were to be interred in Vajdahunyadalso (Romania) beside his first wife, Dr. Magda Vánky (1936–1970), also a physician. Surviving Kálmán are Christine; sons and daughter Dr. Kálmán Vánky Jr., Dr. Tomas Vánky,

Dr. Elisabet Vánky; 10 grandchildren; numerous relatives, mycological colleagues, and friends; and his last wishes in the form of a quote from the Hungarian poet (partly translated by Kálmán himself):

> I have done all I could,
> I have paid those I thought I should.
> I am releasing everyone's tribute and, please,
> Forget the declining earthly copy of my face.

Kálmán, we regret we must use our editorial license to overrule your wishes one last time.

—Lorelei Norvell

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Unless otherwise noted, all facts and photographs above were obtained from Kálmán's still active website: www.kalman-vanky.de/index.html.

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Lamprospora benkertii sp. nov., and an evaluation of *Lamprospora* spp. with *seaveri*-type ascospore ornamentation

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Abstract—*Lamprospora benkertii* is described as a new species based on collections from Georgia, Germany, Norway, Slovakia, and Switzerland. It is characterized by orange apothecia without a fimbriate margin, globose ascospores with a *seaveri*-type ornamentation comprising strong ridges forming a reticulum and a secondary reticulum formed by fine ridges within the meshes of the primary reticulum. The fungus infects rhizoids of *Trichostomum crispulum*. Delineation of the new species is supported by LSU and EF1α sequence analyses. *Lamprospora benkertii* is compared with other *Lamprospora* species with a *seaveri*-type or similar ascospore ornamentation: *L. ascoboloides*, *L. cailletii*, *L. dicranellae*, *L. funigera*, *L. hispanica*, *L. irregulariata*, *L. leptodictya*, *L. norvegica*, *L. paechnatzii*, *L. seaveri*. We also present an updated key for this group of species as well as a more complete description of *L. hispanica* based on our observations from several collections. New host specificity data are provided for *L. hispanica*, *L. leptodictya*, *L. norvegica*, and *L. paechnatzii*.

Key words—bryophilous *Pezizales*, cryptic diversity, host specificity, integrated taxonomy, *Pyronemataceae*

§ ORCID identification numbers [0000-000...]: Eckstein: 2-7214-3321; Vega: 2-0176-9503; Sochorová: 3-0022-9780; Janošik: 2-4001-0145.

Table 1. Sequences of *Lamprospora* spp. and outgroup used in the phylogenetic study.

Species	Herbarium number	Geographic origin (ISO2), collector	LSU	EF1α
L. aff. *seaveri*	PRC 4583	SK, L. Janošík	MN394609	—
	B 70 0100019	AT, M. Vega	MN394595	—
L. ascoboloides	FH KH.03.54	NO, K. Hansen	DQ220358	—
L. benkertii (holotype)	B 70 0100994	DE, J. Eckstein	MN394601	—
	TRH F-10783	NO, S. Sievertsen	MG949136	—
	B 70 0100991	CH, E. Stöckli	MN394592	MN366465
	PRC 4580	SK, L. Janošík	MN394614	—
	B 70 0100982	CH, E. Stöckli	MN394602	MN366469
	B 70 0100987	CH, M. Vega	MN394594	MN366466
	PRM 952409	SK, Z. Egertová, M. Sochor	MN400066	—
	PRM 952408	GE, Z. Egertová	MN394603	—
(as *L. norvegica*)	FH KH.03.138	NO, K. Hansen	KC012684	—
L. cailletii	B 70 0100014	CH, E. Stöckli	MN394604	—
	PRM 951726	SK, Z. Egertová, M. Sochor	MN394605	—
L. dicranellae	HBG 024467	PT, M. Vega	KY858952	—
	HBG 024470	DE, M. Vega	KY858955	—
L. hispanica	B 70 0100992	DE, J. Eckstein	MN400064	MN366467
	B 70 0100985	ES, R. Tena Lahoz	MN394593	—
	B 70 0100998	ES, M. Vega	MN394607	—
	B 70 0100979	ES, R. Martínez-Gil	MN394596	—
	B 70 0100008	ES, M. Vega	MN394598	—
	B 70 0100986	ES, M. Vega	MN394599	MN366468
	B 70 0100980	FR, M. Vega	MN394600	MN366470
	PRM 952410	HR, Z. Egertová, M. Sochor	MN394608	—
L. leptodictya	ZT Myc 61079	CH, E. Stöckli	MN394610	—
	B 70 0100009	FR, M. Vega	MN394611	—
L. norvegica	B 70 0100021	CH, E. Stöckli	MN400065	—
	TRH F-17573	NO, R. Kristiansen	MN394606	—
L. paechnatzii	B 70 0100018	DE, M. Vega, T. Richter	MN394613	—
L. seaveri (holotype)	B 70 0010018	DE, D. Benkert	MN394612	—
	B 70 0100010	DE, M. Vega	MN394597	—
Lamprospora sp.	FH KH.03.131	NO, K. Hansen	DQ220361	—
Octospora leucoloma	PRM 945804	CZ, Z. Egertová	MK569370	—

Introduction

Lamprospora De Not. exhibits a remarkable variability in ascospore ornamentation. Because it may consist of variously shaped ridges, warts, spines, tubercles, and bands, both alone and in combination, ascospore ornamentation is traditionally considered the most important character for species delimitation. In a monographic work, Benkert (1987) distinguished six basic types of ornamentation in *Lamprospora*. One type, characterized by long curved ridges, sometimes forming loops and often tapering at interjections or ends, was termed by him as *seaveri*-type (referring to *L. seaveri*).

In recent years, integrated taxonomy combining traditional morphological studies with new molecular techniques has proved a powerful tool in assessing biodiversity in all groups of organisms (e.g., Caparrós & al. 2016, Deniz & al. 2015, López-Bautista & al. 2006, Nater & al. 2017, Nedeljković & al. 2015, Zhao & al. 2019). Only recently has this approach also been applied to bryophilous *Pezizales* (Vega & al. 2017, 2019, Sochorová & al. 2019). One of the main discoveries from molecular investigations of bryophilous *Pezizales* was the very high host specificity of all investigated species. In consequence, host identity is even more important for delineating bryophilous *Pezizales* species than ascospore ornamentation (Egertová & al. 2018). This makes species reported from multiple, not closely related, hosts likely candidates for hidden diversity and due for evaluation.

Eckstein (2014) reported *Lamprospora hispanica*, one species with *seaveri*-type ascospore ornamentation, as new to Germany, citing collections on *Aloina* sp. and on the hitherto unknown host *Trichostomum crispulum* Bruch (*Pottiaceae*). Since then, we studied many more collections on both hosts and clarified that two species with similar ascospores were at hand. The aim of the present article is to describe the new species on *Trichostomum crispulum* and to compare it with other *Lamprospora* species with *seaveri*-type ascospore ornamentation.

Material and methods

Sample collection and observation

The description of macroscopic and microscopic characters is based on vital material. Microscopic structures were measured in tap water using standard light microscopy. For each collection, at least 20 ascospores and 10 other structures were measured. In all species, ascospore dimensions always include ornamentation, unless stated otherwise. Ascospore ornamentation was studied in cotton blue, and non-amyloidity checked in Lugol´s solution. Scanning electron micrographs (SEM) were taken from air-dried samples.

Herbarium acronyms follow Thiers (2019). Lists of collections are ordered alphabetically by country and from north to south within countries. Collector abbreviations include CN (Csaba Németh), DB (Dieter Benkert), EB (Emiel Brouwer), EP (Eckehard Paechnatz), ES (Elisabeth Stöckli), GE (Günter Eckstein), GM (Gianfranco Medardi), HD (Henry Dissing), JE (Jan Eckstein), LJ (Lukáš Janošík), MdlT (Margarita de la Torre), MS (Michal Sochor), MV (Marcel Vega), RK (Roy Kristiansen), RMG (Rubén Martínez-Gil), RTL (Raúl Tena Lahoz), SS (Sigmund Sivertsen), TR (Torsten Richter), ZE (Zuzana Egertová).

DNA extraction, PCR amplification, sequencing

DNA was extracted from fresh, dried, or CTAB-stored apothecia using the CTAB method (Doyle & Doyle 1987) or the Zymo Research Fungal/Bacterial kit. Amplification was carried out for the 28S subunit of ribosomal DNA (LSU) using primers LR0R and LR6 (Vilgalys & Hester 1990) and for the translation elongation factor-1alpha (EF1α) with primers EF1-983F and EF1–1567R (Rehner & Buckley 2005). PCR was performed with Kapa polymerase, following a standard protocol with 37 cycles and annealing temperature of 56°C. The PCR products were purified by precipitation with polyethylene glycol (10% PEG 6000 and 1.25M NaCl in the precipitation mixture) and sequenced in both directions using the Sanger method (Macrogen Europe, The Netherlands and Sequencing laboratory of the Faculty of Science, Charles University, Prague, Czech Republic).

Phylogenetic analysis

LSU rDNA sequences analyzed included nine sequences of *L. benkertii*, eight of *L. hispanica*, one or two of other *Lamprospora* species with similar ascospore ornamentation, and *Octospora leucoloma* Hedw. as outgroup. Additionally, EF1α was analyzed in selected collections of *L. benkertii* and *L. hispanica*. Along with sequences newly generated in this study, relevant data from the GenBank database were used (https://blast.ncbi.nlm.nih.gov; sequences originate from Perry & al. 2007, Hansen & al. 2013, Vega & al. 2017, and Egertová & al. 2018). Sequences were assembled, edited, and aligned using Geneious (ver. 7.1.7., Biomatters). Bayesian phylogeny inference (BI) was computed in MrBayes (ver. 3.2.4, Ronquist & al. 2012) using the GTR+I+G substitution model, as determined by AICc in jModelTest (ver. 2.1.4, Darriba & al. 2012). The analysis was run for 10 million generations in two independent runs, sampling every 1000th generation and excluding the first 25% of generations as burn-in. Sequences and GenBank accession numbers used in the phylogenetic analysis are listed in Table 1.

Taxonomy

Lamprospora benkertii Eckstein, M. Vega, Sochorová & Janošík, **sp. nov.** Figs 1–4

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Differs from similar *Lamprospora* species by its apothecia without a fimbriate margin, globose ascospores with an alveolate reticulum formed by strong ridges, and infections located on rhizoids of *Trichostomum crispulum*.

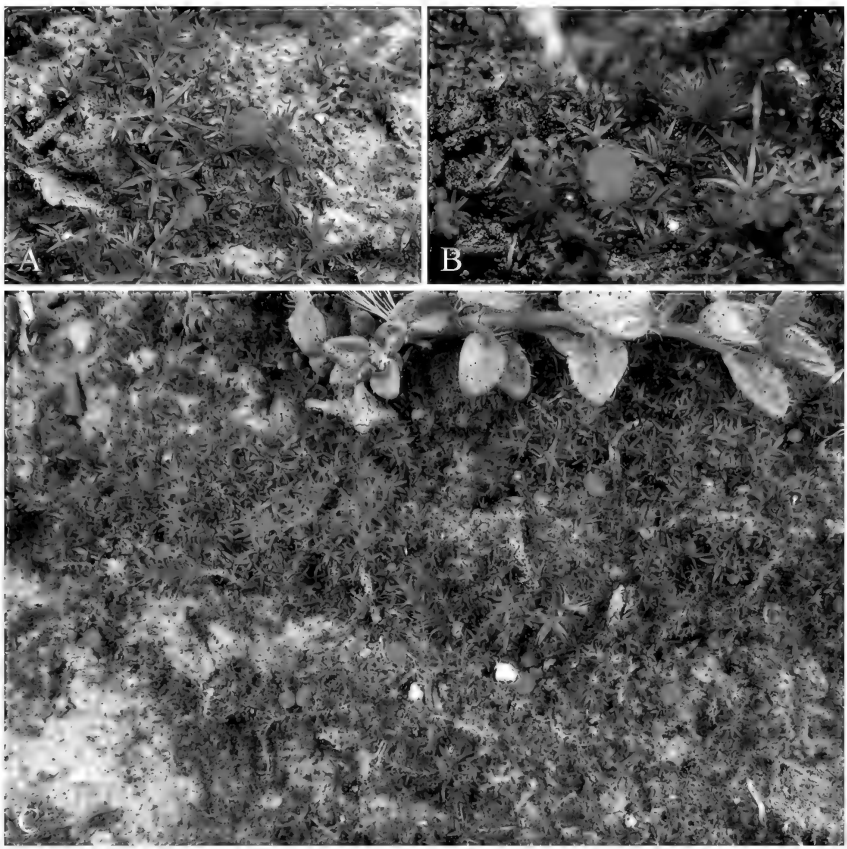

Fig. 1. *Lamprospora benkertii* (A, C. holotype; B. B 70 0100991). Apothecia on soil between shoots of *Trichostomum crispulum*.

Type: Germany, Saxony-Anhalt, Western slope of Spielberger Höhe 1 km ENE Spielberg, 51.3247°N 11.5992°E, 220 m a.s.l., on loamy-calcareous soil with *Trichostomum crispulum, Didymodon fallax,* and *Ephemerum recurvifolium,* 12.VIII.2011, JE22084 (**Holotype**, B 70 0100994).

Etymology: honoring Dieter Benkert for his meritorious service in the taxonomy of bryophilous *Pezizales*

Apothecia gregarious on soil between shoots of *Trichostomum,* (0.2–)0.4–1 (–1.5) mm in diameter, first spherical, becoming cup-shaped, finally discoid with a flat hymenium, sessile, with few hyaline and flexuous anchoring hyphae at the base; margin inconspicuous; hymenium orange to bright orange, outer surface slightly paler.

Asci 180–250(–325) × 18–28 µm, cylindrical to slightly club-shaped, 8-spored, unitunicate, operculate, inamyloid, arising from croziers.

Ascospores uniseriate, hyaline, thin-walled, globose, 13–16.5 µm in diameter (ornamentation included) or 12–14.5 µm without ornamentation, always with a lipid drop, 8–10(–11) µm diameter; ornamentation of the *seaveri*-type consisting of curved ridges approximately 0.8–1.2(–1.6) µm wide and 0.8–1.2 µm high, forming a coarse alveolate reticulum with 4–8 meshes across ascospore diameter, meshes fairly variable and always with a thin secondary net of fine ridges, ridges rarely with loops, sometimes circling the ascospore and rarely ending blind, anastomosing ridges often tapered towards intersection, ornamentation cyanophilous, quickly dissolving in potassium hydroxide (10% KOH).

Paraphyses filiform, straight, pluriseptate, rarely forked and only in lower third, gradually widening from 2.5–3 µm in lower third to 4–6(–8) µm at tip, terminal cell (30–)45–85(–100) µm long, with distinctive carotenoid pigment turning cyan to olivaceous in Lugol's solution, and numerous vacuolar bodies, size ≤4 µm.

Subhymenium consisting of thin-walled, variously shaped, hyaline cells 2.5–6 µm broad, merged with the medullary excipulum; Medullary excipulum about 60–90 µm thick, comprising thin-walled, variously shaped cells forming a textura intricata; Ectal excipulum ca. 40–55 µm thick, comprising thick-walled globose, subglobose to subangular cells (textura subglobulosa), 6–20 × 5–18 µm, cell wall ≤3 µm thick; Margo of parallel hyphae with thick-walled end cells 20–50 × 4–10 µm not (or minimally) protruding over the hymenium (textura prismatica-porrecta).

Infections located on rhizoids of *Trichostomum crispulum*, consisting of mostly 1-celled ellipsoid appressoria, 20–30 × 10–12 µm, sometimes with a somewhat enlarged adjacent cell, initially free, becoming completely covered with anchoring hyphae; infection peg ca. 1 µm wide, surrounded by a tube of rhizoid cell-wall material, forming intracellular haustoria; Penetration point surrounded by a circular thickening of the rhizoid wall; haustoria often ramified with irregular shape and without cross walls, not growing through rhizoid walls; growth modifications with inflated cells and more cross walls

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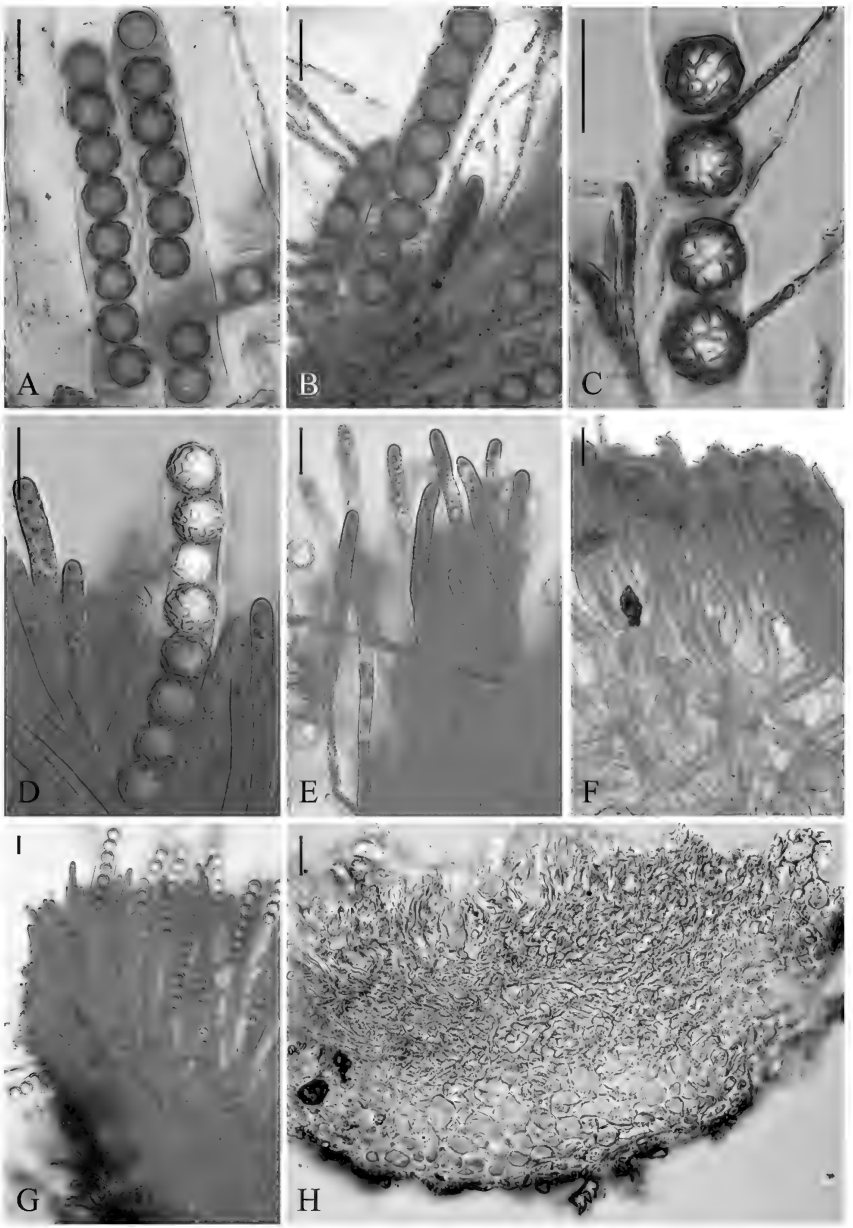
Fig. 2. *Lamprospora benkertii* (A, F, H. holotype; B. B 70 0100987; C. PRC 4580; D, E, G. PRC 4601). A–C. Ascospores stained with cotton blue. D. Ascospores and paraphyses in water. E. Upper part of paraphyses in water. F. Marginal hyphae of an apothecium seen from outside



stained with cotton blue. G. Cross section of a vital apothecium showing margin, excipulum, and hymenium. H. Cross section of a dried apothecium showing subhymenium, medullary, and ectal excipulum. Scale bars = 20 µm.

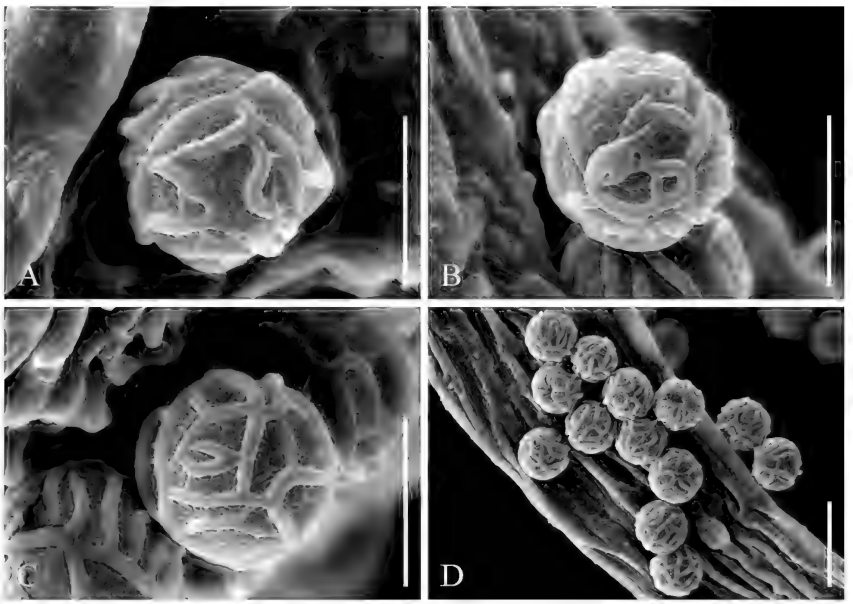


Fig. 3. *Lamprospora benkertii* (A–B. holotype; C–D. B 70 0100987). Ascospores (SEM). Scale bars: A–C. = 10 µm; D. = 20 µm.

than normal sometimes observed on infected and adjacent rhizoid cells; host not weakened discernibly by the infection.

Ecology & distribution—On soil in open situations like grassland, or along tracks and paths together with bryophytes including, apart from the host, *Aloina* spp., *Didymodon fallax, D. acutus, Ephemerum recurvifolium,* and *Weissia longifolia.* Known from Georgia, Germany, Norway, Slovakia, and Switzerland.

Additional specimens examined—**GEORGIA. Racha-Lechkhumi and Kvemo Svaneti, Racha mountains,** 5 km E of Shovi, 42.6911°N 43.7317°E, 2240 m a.s.l., 27.VI.2014 ZE (PRM 952408). **GERMANY. Saxony-Anhalt, NE Grockstädt,** 51.3331°N 11.5931E, 220 m a.s.l., on calcareous soil in dry grassland, 21.VIII.2017 JE51316 (B 70 0100984); **2.35 km NNE Reinsdorf,** 51.3128°N 11.6183°E, 195 m a.s.l., on south-facing slopes of loess-soil with *Trichostomum crispulum*, 11.X.2011 JE22454 (B 70 0100996). **NORWAY. Nordland, Saltdal,** Junkerdalen, Gammelveien innenf. bommen, 120 m a.s.l., between mosses on track, 31.VIII.1988 SS88-78 (TRH F-10783 as *Lamprospora* cf. *ascoboloides*); 29.VIII.1998 HD&SS98-14 (TRH F-10639 as *Lamprospora ascoboloides*). **SLOVAKIA. Žilina, Súľov-Hradná,** 49.1576°N 18.5808°E, 425 m a.s.l., margin of a forest way, 20.VIII.2016, ZE (PRM 952409); **Trenčín, Trenčín,** 48.8876°N 18.0610°E, 220 m a.s.l., between mosses on the margin of a small forest path,

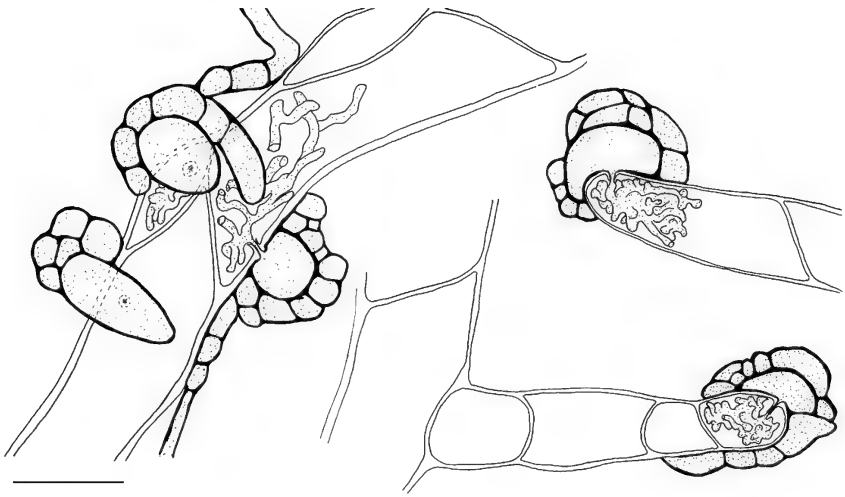


Fig. 4. *Lamprospora benkertii* (holotype). Several infectious structures in optical section on rhizoids of *Trichostomum crispulum*; fungal cells dotted. Scale bar = 20 μm.

10.XII.2014 LJ (PRC 4579); **Beckovské Skalice,** 48.7744°N 17.8944°E, 220 m a.s.l., on path in grassland, 07.X.2014 LJ (PRC 4580); 27.X.2019 LJ (PRC 4601). **SWITZERLAND. Bern, Gasteretal,** 46.4672°N 7.6611°E, 1350 m a.s.l., on soil, 30.IX.2016 ES (B 70 0100991); **Kandersteg,** 46.4744°N 7.6572°E, 1240 m a.s.l., on soil in grazing land, 25.VIII.2018 MV180825-2 (B 70 0100987); 46.4447°N 7.7225°E, 1580 m a.s.l., on soil in grazing land, 04.X.2013 ES (B 70 0100982).

Phylogenetic analysis—*Lamprospora benkertii* forms a well-supported clade with very little polymorphism among individual collections (Fig 5). In LSU, five collections are fully identical (MN394601 – holotype, MN400066, MN394592, MN394614, and MN394602), with three others differing only in a single nucleotide (MG949136, MN394603 and KC012684 — published as *L. norvegica* by Hansen & al. 2013) and one other in another single nucleotide (MN394594). *Lamprospora paechnatzii* was identified as the closest relative of *L. benkertii; L. hispanica,* which is morphologically very similar to *L. benkertii,* differs strongly both in LSU and EF1α (data not shown). A similar phenomenon was also observed in *L. seaveri* sensu lato, which was described as associated with *Ceratodon purpureus* and *Bryum* sp. (Benkert 1987); however, collections from these two hosts form independent lineages.

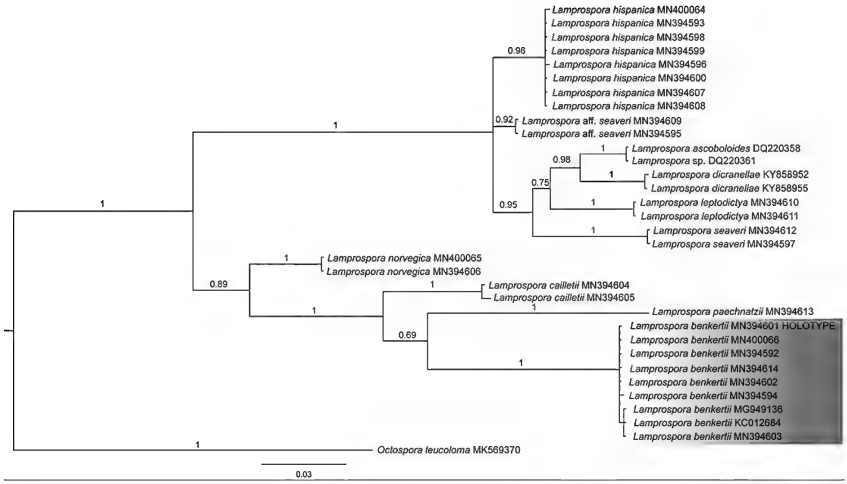


FIG. 5. Bayesian phylogram of *Lamprospora* spp. based on LSU rRNA sequences, with *Octospora leucoloma* as outgroup. Bayesian posterior probabilities are shown above branches.

COMMENTS—*Trichostomum crispulum*, the host of the new *L. benkertii*, is not known as a host of other bryophilous *Pezizales*. It has a circumpolar southern-temperate distribution with occurrences in Europe, Asia Minor, Siberia, East Asia, New Guinea, Macaronesia, North and Central Africa, Newfoundland, and Central America (Smith 2004).

In his main contribution to the taxonomy of *Lamprospora*, Benkert (1987) listed six species with *seaveri*-type ascospore ornamentation: *L. cailletii*, *L. hispanica* and *L. seaveri*, as well as *L. ascoboloides*, *L. leptodictya* and *L. paechnatzii*. The first three species were assigned to the subtype '*seaveri,*' characterized by anastomosing ridges forming an alveolate reticulum, and the latter three to the subtype '*paechnatzii*', delineated by only partly anastomosing ridges not forming a reticulum. Subsequently, another species, *L. norvegica,* was also described with *seaveri*-type ornamentation (Benkert & al. 1991).

Two little known species, *L. irregulariata* from India and *L. funigera* from Australia, also must be considered in this context. Additionally, we include *L. dicranellae* Benkert in this discussion, because in the past it has frequently been mistaken for *L. ascoboloides*. We discuss these species in alphabetical order below with delineations based on our own observations except for *L. funigera* and *L. irregulariata*.

Lamprospora ascoboloides Seaver, Mycologia 6: 10. 1914.

Based on collections from the US states Connecticut, New York, and Virginia, *L. ascoboloides* is characterized by globose ascospores 13–15(–17) µm in diameter [12–14 µm in Benkert (1987) and (14–)16–18 µm incl. ornamentation in Wang & Kimbrough (1992)], ornamented by curved ridges 1–2 µm wide and 1–1.5(–2) µm high that often end bluntly and do not (or hardly) form a rudimentary reticulum (Seaver 1914, Benkert 1987, Wang & Kimbrough 1992). Furthermore, the ornamentation lacks warts. Our study of the NY type material revealed a dicranelloid moss as the host. (probably *Dicranella heteromalla,* but with juvenile shoots too small for certain identification). Notably, the infection induces spherical galls 40–80 µm in diameter on the rhizoids. These rhizoid galls are completely covered with a layer of hyphae. *L. ascoboloides* differs from *L. benkertii* in broader ridges and the host.

The name *L. ascoboloides* was later applied many times to collections with strong, curved ridges as ascospore ornamentation, but critical studies of these specimens always led to other identifications. For instance, *L. ascoboloides* in reports by Caillet & Moyne (1980) was later re-determined by Benkert (1987) as *L. dicranellae*. The description and illustrations of '*L. ascoboloides*' by Schumacher (1993) also clearly show *L. dicranellae*. Our revision of *L. ascoboloides* specimens in TRH indicated mostly *L. dicranellae* or rarely *L. arvensis* (Velen.) Svrček as well as several yet undescribed species. We also revised a specimen from K (listed in Medardi 2006) to *L. dicranellae*. We also studied two collections sequenced by Perry & al. (2007, GenBank accession numbers DQ220358 and DQ220361) that also have *L. dicranellae*-like ascospores, but their sequences do not cluster with other *L. dicranellae* samples (Vega & al. 2017), clearly indicating that further study is needed. *Dicranella* species were not found as hosts in any of these cases. Medardi (2005) reported *L. ascoboloides* from Italy accompanied by *Dicranella*, *Ditrichum*, *Riccia*, and *Anthoceros*. Unfortunately, our investigation of MCVE 15993 resulted in no unambiguous observation of the infection but the host is most likely *Dicranella* or *Ditrichum*. Therefore, the specimen could represent *L. ascoboloides* but without definite identification of the host, its identity remains unclear. Hopefully, future collections from both North America and Europe will shed light on this subject.

Specimens examined (for revised specimens see *L. dicranellae*)—**ITALY. Lombardy**, **Calvagese**, Brescia, 300 m a.s.l., with *Dicranella*, *Ditrichum*, *Riccia*, and *Anthoceros*, 09.VI.2001 GM (MCVE 15993 as *L. ascoboloides*).

Lamprospora cailletii Benkert, Z. Mykol. 53: 211. 1987.

Based on a collection from the French Alps, *L. cailletii* is characterized by 1–2 mm diameter yellow-orange apothecia with small fimbriate margins, globose ascospores (14)15–16.5(17) µm, ornamented by curved ridges 0.8–1.5 µm wide and high forming a reticulum and additional warts, and *Tortella tortuosa* as host (illustrations in Kristiansen 2006, Stöckli 2016). The additional warts are sometimes difficult to see, and then the ascospore ornamentation looks very similar to that of *L. benkertii*. It further differs from *L. benkertii* by the small apothecial margins, slightly larger ascospores, lack of secondary reticulum, and identity of the host.

Formerly *L. cailletii* was only rarely reported from France and Germany (Benkert 1987), Norway (Kristiansen 2006), and Switzerland (Stöckli 2016). Newly, we report it from Slovakia. We doubt that the report on *Ditrichum flexicaule* (Schwägr.) Hampe by Schumacher (1993) from France is actually from this species.

Selected specimens examined—**SLOVAKIA. Žilina, Terchová,** 1870 m SSW of St. Cyril and Metod´s church, Malá Fatra NP, 49.2417°N 19.0261°E, 935 m a.s.l., on soil with *Tortella tortuosa*, 29.X.2016, ZE & MS (PRM 951726). **SWITZERLAND. Jura, Montfaucon,** 47.2755°N 7.0793°E, 930 m a.s.l., host *Tortella tortuosa*, 18.X.2015 ES (B 70 0100014).

Lamprospora dicranellae Benkert, Z. Mykol. 53: 217. 1987.

Based on collections from the Czech Republic, Germany, Denmark, France, Norway, and Sweden, *L. dicranellae* is characterized by orange apothecia 1–3 mm in diameter with conspicuous fimbriate margins, globose ascospores (14)15–16.5(17) µm, ornamented by curved ridges 1–2 µm wide and high forming a reticulum and additional warts (Fig. 7A). The host is not *Dicranella* as assumed in the protologue but *Ditrichum heteromallum* and *D. pusillum* (Eckstein & al. 2014, Vega & al. 2017). *L. dicranellae* differs from *L. benkertii* by its larger apothecia with conspicuous fimbriate margins, the existence of many prominent warts in addition to curved ridges on the ascospore surface, and identity of the host.

Lamprospora dicranellae is a relatively widespread species with further occurrences not mentioned in the protologue, e.g., in Austria and on the Canary Islands and Madeira (Korf & Zhuang 1991) and in Great Britain (Yao & Spooner 1995), the Netherlands (Brouwer 1999), Spain (Rubio & al. 2002), and the USA (Wang & Kimbrough 1992).

Selected specimens examined—**AUSTRIA. Carinthia, Nockberge,** above Zechneralm, 46.9494°N 13.7576°E, 1970 m a.s.l., 10.VIII.2015 JE42349 (B 70 0100988). **Salzburg, Uttendorf, Staubachtal,** on sandy soil near mosses, 18.VIII.2005 GM (K[M] 138534 as *L. ascoboloides*). **GERMANY. Thuringia, Eisenach,** S Wartburg, 50.9581°N 10.2998°E, 280 m a.s.l., host *Ditrichum* sp., 27.IX.2017 JE51668 (B 70 0100989). **NORWAY. Oppland, Vang,** Tyinholmen, 1100 m a.s.l., host *Ditrichum* cf. *pusillum*, 23.VIII.1986 RK (TRH F-9757 as *L. ascoboloides*).

Lamprospora funigera McLennan & Cookson, Proc. Roy. Soc. Victoria 38: 70. 1926.

Based on two collections from the state Victoria in Australia, *L. funigera* is characterized by apothecia 1–3 mm in diameter with well-developed fimbriate margins, globose ascospores 12–13 µm in diameter, ornamented by curved ridges forming a reticulum. The host is unknown. It differs from *L. benkertii* in larger apothecia with a conspicuous fimbriate margin and smaller ascospores. So far *L. funigera* is only known from the type specimen (McLennan & Cookson 1926).

Lamprospora hispanica Benkert, Z. Mykol. 53: 227. 1987. Figs 6, 7B

This species is based on one collection from Spain. Studying the holotype in MA we found some differences between the original description and our observations later confirmed by many identical collections from different countries. Because of the partly incorrect original description, we provide here a more complete description based on our own observations (Fig. 6, 7B):

Apothecia gregarious, occasionally packed, on soil between shoots of *Aloina*, 1–2(3) mm in diameter, at first spherical, becoming cup-shaped, finally thick and discoid with a flat hymenium, sessile, with hyaline and flexuous anchoring hyphae; margin conspicuous, fimbriate to shaggy; hymenium varying from pale orange to orange, margin and outer surface paler.

Asci 250–450 × 20–28 µm, cylindrical, 8-spored, unitunicate, operculate, inamyloid, bifurcate at the base, arising from croziers.

Ascospores subglobose, hyaline, uniseriate, 16–19(22) × 15–18(20) µm (ornamentation included), Q: 1.03–1.06(1.1), always with a lipid drop (10)11–13 µm in diameter; ornamentation consisting of an alveolate reticulum of the *seaveri*-type, with 5–8(10) meshes across ascospore diameter, with the net's density varying considerably between collections, meshes fairly variable, often with lower and thinner ridges that may form a secondary net, ascospore surface slightly roughened with occasionally minute stains, main

ridges approximately 0.8–1.0 µm wide and 0.6–0.8(1) µm high, sometimes with loops, anastomosing ridges not or rarely tapering at interjections.

Paraphyses filiform, straight, pluriseptate, branched at the base, gradually enlarging towards the apex, terminal cell 50–120 × 4–8 µm, distinctive carotenoid pigment turning cyan to olivaceous in Lugol's solution, at times in lipid bodies, numerous vacuolar bodies ≤4 µm in size.

Medullary excipulum textura intricata; ectal excipulum textura prismatica-angularis; margo textura prismatica-porrecta, cells 36–120 × 10–30 µm.

Infection on strong rhizoids of *Aloina aloides* (Koch ex Schultz) Kindb. or *Aloina ambigua* (Bruch & Schimp.) Limpr. consisting of appressoria, infection peg and haustoria; appressoria clearly differentiated, attached to the rhizoid becoming completely covered which anchoring hyphae, 30–60(75) × 25–35(50) µm in side view, mostly 2-septate, often multiple infection pegs originating from one appressorium.

Ecology & distribution—*L. hispanica* occurs on soil in open and mostly warm habitats such as in dry grassland, in cemeteries, or along paths. It does not seem to be rare in Spain (Ortega & Vizoso 1991, Martínez-Gil & Caballero 2015). Additional collections have been made in Croatia, Cyprus, France, Germany, Hungary, Portugal, and The Netherlands, with distribution seemingly centered in the Mediterranean region with scattered occurrences further north in the temperate zone. Given its known distribution, it is possible that the species might occur in all Central and Southern European countries.

Lamprospora hispanica differs from *L. benkertii* by its larger apothecia with conspicuous fimbriate margins, its slightly subglobose ascospores with more uniformly wide ridges forming a denser net, its much larger appressoria, and the identity of its host.

Selected specimens examined—**CROATIA. Karlovac, Modruš** rest area, 45.1301°N 15.2483°E, 500 m a.s.l., on soil with *Aloina* sp., 20.XI.2016 ZE (PRM 952410). **CYPRUS. Paphos, Peiya,** 34.8936°N 32.3794°E, 440 m a.s.l., on soil layer on stone wall, host *Aloina* sp., 28.II.2019 MV190228-07 (B 70 0100981). **FRANCE. Gironde, Cenon,** Parc Palmer, 44.8611°N 0.5261°W, 55 m a.s.l., slope beside a path, host *Aloina ambigua*, 06.IV.2018 MV180406-01 (B 70 0100978). **Haute Garonne, Toulouse,** cemetery of Terre-Cabade, 43.6067°N 1.4603°E, 170 m a.s.l., on soil between graves, host *Aloina ambigua*, 14.II.2017 MV170214-03 (B 70 0100980). **GERMANY. Hesse, Werra valley,** Weinberg W Jestädt, 51.2188°N 9.9955°E, 180 m a.s.l., on soil in dry grassland, host *Aloina ambigua*, 18.I.2014 JE34631 (B 70 0100990); **Lower Saxony, N Tettenborn,** 51.5716°N 10.5534°E, 320 m a.s.l., in an old quarry on loamy soil with

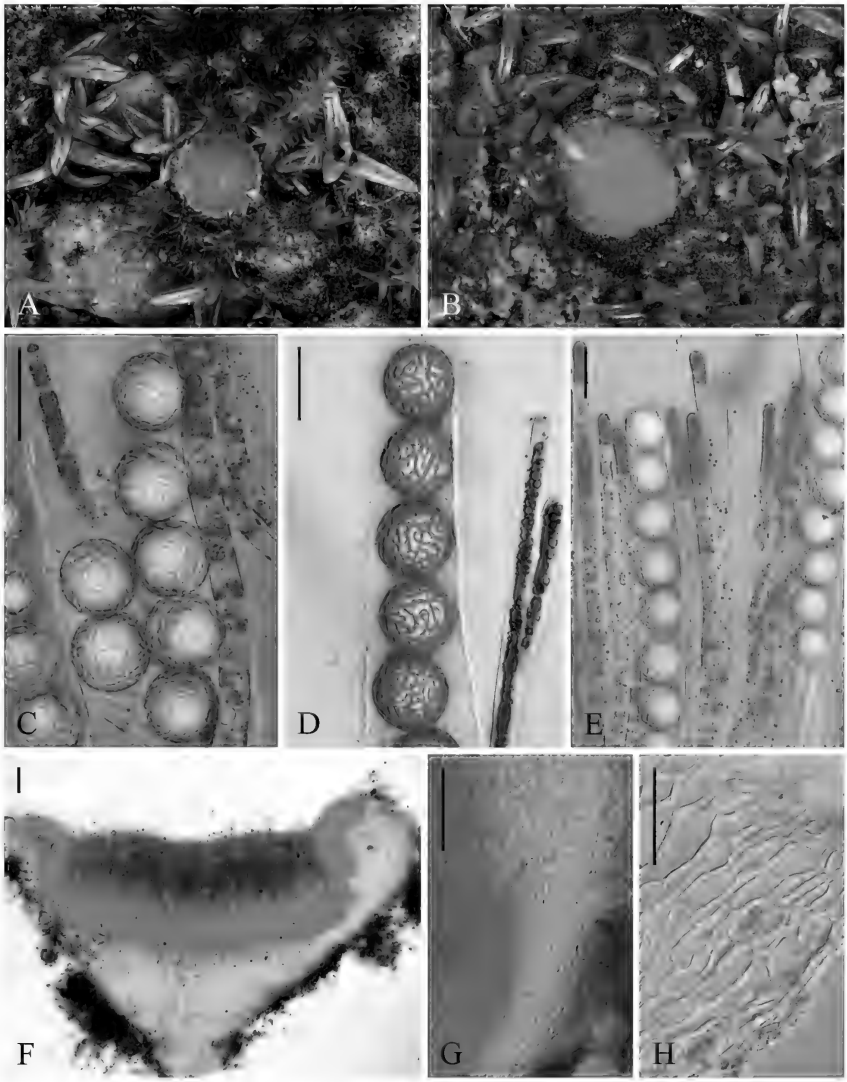


Fig. 6. *Lamprospora hispanica* (A. B 70 0100990; B–H. B 70 0100980). A, B. Apothecia on soil with shoots of *Aloina* sp. C. Ascospores in water. D. Ascospores stained with cotton blue. E. Paraphyses and asci in water. F. Cross section of an apothecium. G. Medullary excipulum next to the hymenium. H. Cross section of upper margin of an apothecium. Scale bars: C–E. = 20 µm; F–H. = 100 µm.

gypsum, host *Aloina aloides*, 22.XI.2016 JE49371 (B 70 0100992). **HUNGARY. Fejér, Vèrtes Mts.**, Csàkvòr, Szòlò-Kö. 47.3804°N 18.4374°E, 200 m a.s.l., host *Aloina ambigua*, 05.III.2016 CN7751 (private herbarium CN). **PORTUGAL. Lisboa, Cémiterio do Alto de São João,** 38.7303°N 9.1206°W, 70 m a.s.l., on soil between graves, host *Aloina ambigua*, 25.I.2014 MV140125-13 (B 70 0100995). **SPAIN. Aragón, Teruel,** Calle Bajo Los Arcos, 40.3458°N 1.1058°W, on soil in front of a house, host *Aloina ambigua*, 30.IX.2015 RTL15093001 (B 70 0100985); **La Rioja, Logroño,** Parque La Grajera, 42.4464°N 2.5078°W, 440 m a.s.l., on soil between trees of *Populus* sp., 05.XII.2014 RMG (B 70 0100979); **Madrid, Aranjuez,** 06.III.1975 MdlT (MA-Fungi 2359, holotype); **Mallorca, Inca,** Parque Llubi Torradas, 39.7064°N 2.9967°E, 80 m a.s.l., below a tree, host *Aloina* sp., 01.XII.2017 MV171201-06 (B 70 0100983); **Palma de Mallorca,** Placa del Rentadors, 39.5694°N 2.6389°E, 10 m a.s.l., amenity land, host *Aloina ambigua*, 22.I.2017 MV170122-03 (B 70 0100986); **País Vasco, Parque Ribera,** host *Aloina ambigua*, 23.I.2016 MV160123-02 (B 70 0100008)**; Urkiola,** Calle Barrio de Urkiola, 43.1003°N 2.6447°W, 730 m a.s.l., bank alongside the road, host *Aloina aloides*, 19.VI.2018 MV180619-01 (B 70 0100998). **THE NETHERLANDS. Zeeland, Oosterschelde-dam**, south of Burgh-Haamstede, on Neeltje-Jans near Expo, 1 m a.s.l., on sandy recreation area, partly covered with gravel, host *Aloina ambigua*, 31.XII.2008 EB270 (private herbarium EB).

Lamprospora irregulariata K.B. Khare & V.P. Tewari, Mycologia 70: 885. 1978.

Based on a collection from Mussoorie in the state Uttarakhand in northern India, *L. irregulariata* is characterized by apothecia 2–3 mm in diameter, a yellow-white hymenium, globose ascospores 13–16 µm, ornamented by thick curved ridges forming an incomplete reticulum. The host is not known. The yellow white color of the hymenium set this species clearly apart from *L. benkertii* and even raises doubts in its affiliation to the genus *Lamprospora*. It is known only from the type (Khare & Tewari 1978).

Lamprospora leptodictya Dissing, Mycologia 73: 263. 1981.

Based on a collection from Greenland, *L. leptodictya* is characterized by apothecia 0.8–1.8 mm in diameter with conspicuous fimbriate margins, an orange hymenium, subglobose ascospores, 15–17 × 13–15.5 µm, Q ≤1.1, ornamented with curved, often blunt ending and tapering and only partly anastomosing ridges 0.5–0.9 µm wide and 0.5 µm high (Fig. 7C), and its host *Aongstroemia longipes* (Sommerf.) Bruch & Schimp. It differs from *L. benkertii* by its subglobose ascospores, smaller ridges not forming a reticulum, and its host.

Dissing notes *A. longipes* and *Bryum* sp. as accompanying bryophytes. Benkert (1987) studied a later collection from the type locality and suspected

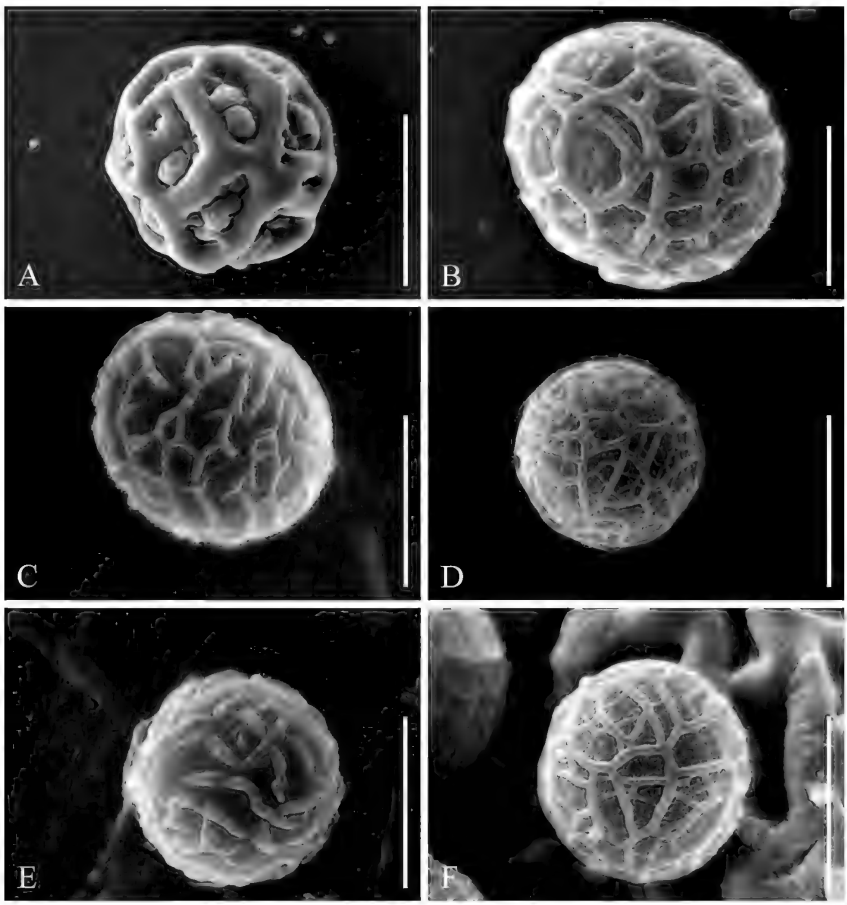


FIG. 7. SEM of ascospores of species similar to *Lamprospora benkertii*. A. *L. dicranellae* (B 70 0100989); B. *L. hispanica* (B 70 0100998); C. *L. leptodictya* (B 70 0100009); D. *L. norvegica* (B 70 0100021); E. *L. paechnatzii* (private herbarium TR 22VI2014, s.n.); F. *L. seaveri* (B 70 0010018, holotype). Scale bars = 10 μm.

Bryum sp. as host but could not actually find the infection. In specimens from the French and Swiss Alps we confirmed *A. longipes* as the host. The ornamentation is similar to that of *L. paechnatzii* with often short and blunt ending ridges not or hardly forming a reticulate pattern.

Based on the few reports and the distribution of the host moss, *L. leptodictya* is an arctic-alpine species, known from Greenland (Dissing 1981), Norway (Schumacher 1993), France (Van Vooren 2017), and Switzerland.

Specimen examined—**FRANCE. Savoy, Bonneval-sur-Arc**, Ruisseau de Céma,45.4250°N 7.0419°E, 2740 m a.s.l., host *Aongstroemia longipes*, 26.VIII.2015 MV20150826-01 (B 70 0100009). **SWITZERLAND. Bern, Guttannen**, Oberaarstausee, 46.5474°N 8.2769°E, 2306 m a.s.l., host *Aongstroemia longipes*, 18.VIII.2014 ES (ZT Myc 61079).

Lamprospora norvegica Benkert, Aas & R. Kristiansen, Z. Mykol. 57: 196. 1991.

Based on collections from mainland Norway, *L. norvegica* is characterized by apothecia 0.7–1.0(1.5) mm in diameter with conspicuous fimbriate margins, an orange hymenium, globose to slightly subglobose ascospores, 13–14 × 12–13 µm (Q ≤1.08), ornamented with curved ridges 0.3–0.7 µm wide and 0.5 µm high forming a reticulum (Fig. 7D). It differs from *L. benkertii* by slightly subglobose ascospores, smaller ridges, and host.

Benkert & al. (1991) suspected *Pohlia filum* as host but could not actually prove this. We studied collections from Norway and Switzerland and in two collections, we could identify *Ditrichum pusillum* (Hedw.) Hampe as host. The infection causes the swelling of infected rhizoid cells forming spherical galls.

Lamprospora norvegica is known from Norway (Benkert & al. 1991), Svalbard (Schumacher 1993), and Switzerland.

Specimens examined—**NORWAY. Buskerod, Hol**, Raggsteindalsvegen, 60.6666°N 7.8147°E, 1000 m a.s.l., host *Ditrichum pusillum*, 01.VIII.2015 RK (TRH F-17572). **Hordaland, Ulvik**, Finse, near Finse railway station, 60.60°N 7.50°E, 1300 m a.s.l., host probably *Ditrichum pusillum*, 24.VIII.2008 RK29/06 (TRH F-17573). **SWITZERLAND. Bern, Gadmen**, Steingletscher, 46.7233°N 8.4340°E, 1930 m a.s.l., host *Ditrichum pusillum*, 17.VII.2014 ES (B 70 0100021).

Lamprospora paechnatzii Benkert, Z. Mykol. 53: 237. 1987.

Based on a collection from the German lowlands *L. paechnatzii* is characterized by apothecia 1–2 mm in diameter, with low but conspicuous fimbriate margins, a yellow to yellowish orange hymenium, globose ascospores (14–16 µm in diameter) ornamented with curved often blunt ending and tapering ridges 0.3–0.8 µm wide and high, short and often S-shaped, rarely anastomosing and not forming a reticulum (Fig. 7E), and the host *Bryum archangelicum* Bruch & Schimp. It differs from *L. benkertii* by smaller ridges not forming a reticulum and the host.

Benkert reports *Bryum* sp. as the host; but our examination of the type specimen revealed *B. archangelicum* as the host moss.

Lamprospora paechnatzii is known from Germany and the Czech Republic (Benkert (1987) and Spain (Rubio & al. 2002).

Specimens examined—GERMANY. **Brandenburg**, **Bernau**, Kiesgrube Schwanebeck-Alpenberge, host *Bryum archangelicum*, VII.1978 EP (B 70 0010013, holotype); **Mecklenburg-Western Pomerania**, **Lützow**, gravel pit N Pokrent, host *Bryum* sp., 22.VI.2014 TR (private herbarium TR); host *Bryum* sp., 05.VIII.2014 MV140805-04 (B 70 0100018).

Lamprospora seaveri Benkert, Z. Mykol. 53: 241. 1987.

Based on many collections from Central and Northern Europe, *L. seaveri* is characterized by orange apothecia 1–4 mm in diameter with conspicuous fimbriate margins, an orange hymenium, globose ascospores 14–16 µm in diameter with an ornamentation consisting of fine ridges 0.3–0.8 µm wide and high forming a reticulum, often with a secondary reticulum within the meshes (Fig. 7F), and the host *Ceratodon purpureus*. It differs from *L. benkertii* by its larger apothecia with a conspicuous margin, smaller ridges, and host identity.

Benkert (1987) mentions the misapplication of the name *Lamprospora laetirubra* (Cooke) Lagarde for this species; the type of the basionym *Peziza laetirubra* Cooke is conspecific with *Pulvinula cinnabarina* (Fuckel) Boud. Although the designated holotype of *L. seaveri* has *Ceratodon purpureus* as host, Benkert (1987) also listed many collections on *Bryum* sp. among the paratypes. As stated in the introduction, multiple unrelated hosts of a species often indicate unresolved taxa. The ascospores of collections from *C. purpureus* and from *Bryum dichotomum* are indeed very similar, and variations in ascospore size and ornamentation partly overlap. Nevertheless, our suspicion of hidden diversity is also supported by molecular data (Fig. 5, *L.* aff. *seaveri*), which indicate an independent taxon on *Bryum dichotomum*. Because of mostly scant collections on this host, description of *L.* aff. *seaveri* must be addressed in a later study. For the meantime, we recommend that only collections on *C. purpureus* be identified as *L. seaveri*.

Selected specimens examined—**AUSTRIA. Vienna**, **Central Cemetery**, host *Ceratodon purpureus*, 01.XII.2014 MV141201-02 (B 70 0010019). **GERMANY. Brandenburg**, **Potsdam**, slope along railway embankment at Berlin ring road near bridge across Caputher Chaussee, host *Ceratodon purpureus*, 23.XI1.986 DB (B 70 0010018, holotype). **Saxony-Anhalt**, **Galgenberg**, NE Elbingerode, host *Ceratodon purpureus*, 10.X.2015 GE (B 70 0100997). **Schleswig-Holstein**, **Appen**, host *Ceratodon purpureus*, 08.XI.2015 MV151108-01 (B 70 0100010). **Thuringia**, **S Wipperdorf**, 51.4463°N 10.6425°E, 240 m a.s.l., host *Bryum dichotomum*, 13.X.2017 JE51710 (B 70 0100993). **MONTENEGRO. Andrijevica Municipality**, **Štavna plateau**, 42.6988°N 19.6745°E, 1820 m a.s.l., between mosses on the edge of the pathway on mountain pasture, host *Ceratodon purpureus*, 18.VI.2017 LJ (PRC 4581).

Table 2. Comparison of main features of *Lamprospora* spp. with *seaveri*-type or similar spore ornamentation. (Measurements based on our observations, except for *L. funigera* and *L. irregulariata*.)

Lamprospora species	Apothecial diameter	Conspicuous fimbriate margin	Ascospores	Ornamentation	Host (moss family)
benkertii	0.4–1 mm	–	Globose, 13–16.5 µm	Main ridges 0.8–1.2 µm wide and high, forming a reticulum	*Trichostomum crispulum* (*Pottiaceae*)
ascoboloides	no data	–	Globose, 13–15 µm [12–14 µm in Benkert (1987)]	Ridges 1–2 µm wide, 1–1.5 high; often with blunt ends not forming a reticulum	cf. *Dicranella heteromalla* (*Dicranaceae*)
cailletii	1–2 mm	±	Globose, 15–16.5 µm	Ridges ≤0.8–1.5 µm wide & high, forming a reticulum; additional warts within the meshes of the reticulum	*Tortella tortuosa* (*Pottiaceae*)
dicranellae	1–3 mm	+	Globose, 15–16.5 µm	Ridges 1–2 µm wide & high, forming a rudimentary reticulum; numerous prominent warts	*Ditrichum heteromallum*, *D. pusillum* (*Ditrichaceae*)
funigera	1–3 mm	+	Globose, 12–13 µm	Fine ridges forming a reticulum	—
hispanica	1–2 mm	+	Subglobose, 16–19×15–18 µm, Q = 1.03–1.06	Main ridges 0.8–1.0 µm wide, 0.6–0.8 µm high, forming a dense reticulum	*Aloina aloides*, *A. ambigua* (*Pottiaceae*)
*irregulariat*a	2–3 mm	–	Globose, 13–16 µm	Main ridges ca. 1 µm wide & high, forming an incomplete reticulum	—
leptodictya	0.8–1.8 mm	+	Subglobose, 15–17×13–15.5 µm, Q to 1.1	Ridges 0.5–0.9 µm wide, ≤0.5 µm high, not or rarely forming a reticulum	*Aongstroemia longipes* (*Dicranaceae*)
norvegica	0.7–1 mm	+	Slightly subglobose 13–14×12–13 µm, Q to 1.08	Ridges 0.3–0.7 µm wide, ≤0.5 high, forming a reticulum	*Ditrichum pusillum* (*Ditrichaceae*)
paechnatzii	1–2 mm	±	Globose, 14–16 µm	Ridges 0.3–0.8 µm wide & high, short & often S-shaped, rarely anastomosing, not forming a reticulum	*Bryum archangelicum* (*Bryaceae*)
seaveri	1–4 mm	+	Globose, 14–16 µm	Main ridges 0.3–0.8 µm wide & high, forming a reticulum, often with secondary reticulum	*Ceratodon purpureus* (*Ditrichaceae*)

The main features of the mentioned species are summarized in Table 2. To facilitate identification, we provide a new key.

Key to species of *Lamprospora* with *seaveri*-type (or similar) ascospore ornamentation

1. Hymenium yellow-white, apothecia 2–3 mm in diameter, little known species from India (possibly not belonging to *Lamprospora*) ... ***L. irregulariata***

1. Hymenium shades of orange ... **2**

2. Ascospores with main ridges 1–2 µm wide and many prominent warts between the ridges, host *Ditrichum* spp. ... ***L. dicranellae***

2. Ascospores with different ornamentation or host ... **3**

3. Ascospores ornamented by often blunt ending ridges not or hardly forming a reticulum ... **4**

3. Ascospores ornamented by anastomosing ridges forming a reticulum ... **6**

4. Ridges of ascospore ornamentation strong, 1–2 µm wide, ascospores globose, 13–15(–17) µm, host probably *Dicranella heteromalla* ... ***L. ascoboloides***

4. Ridges of ascospore ornamentation weaker, 0.3–0.9 µm wide, a scospores globose or slightly subglobose ... **5**

5. Ascospores mostly subglobose, 15–17 × 13–15.5 µm, host *Aongstroemia longipes*, in arctic–alpine habitats ... ***L. leptodictya***

5. Ascospores globose, 14–16 µm, host *Bryum archangelicum*, in the temperate zone ... ***L. paechnatzii***

6. Apothecia with conspicuous fimbriate margins, ascospores subglobose, 16–19(–22) × 15–18(–20) µm, host *Aloina* spp. ... ***L. hispanica***

6. Other combination of characters ... **7**

7. Main ridges of ascospore ornamentation 1 µm wide or wider ... **8**

7. Main ridges of ascospore ornamentation 0.3–0.8(–1) µm wide ... **9**

8. Main ridges of ascospore ornamentation 0.8–1.5 µm wide with additional warts (difficult to observe), host *Tortella tortuosa* ... ***L. cailletii***

8. Main ridges of ascospore ornamentation about 1 µm wide often with a secondary reticulum within the meshes, host *Trichostomum crispulum*, southern-temperate distribution ... ***L. benkertii***

9. Apothecia ≤1 mm, ascospores often slightly subglobose, 13–14 × 12–13 µm, host *Ditrichum pusillum*, in arctic-alpine habitats ... ***L. norvegica***

9. Apothecia mostly >1 mm, host and habitat different ... **10**

10. Ascospores globose, 12–13 µm, little known species from Australia, host unknown ... ***L. funigera***

10. Ascospores globose, 14–18 µm, host *Ceratodon purpureus* or *Bryum* spp. ... **11**

11. Ascospores globose, 14–16 µm,
host *Ceratodon purpureus* ..... ***L. seaveri***
11. Ascospores globose or slightly subglobose, 14–18 µm,
host *Bryum* spp. ..... ***L.* aff. *seaveri***

There are several unpublished collections on different hosts with a *seaveri*-type ascospore ornamentation that cannot be ascertained as conspecific with any of the above-mentioned species. Because of these scant collections, no further details are provided here, but these unresolved specimens indicate a higher diversity in this group than previously thought.

Both morphological and molecular data confirm the very high host specificity of the bryophilous *Pezizales*. All evaluated species grow only on one particular moss species or on very closely related species as is the case with *L. hispanica* with hosts *Aloina aloides* and *A. ambigua*. In *L. seaveri*, which was reported from multiple hosts, the phylogenetic analysis clearly shows the presence of at least one other species on *Bryum dichotomum* (Fig. 5).

Although an identification of species can be undertaken by morphological characters only (Table 2), differences between species are sometimes subtle and variations of some features can overlap. The easiest way to differentiate between species is to consider the ecology and host identity. Specimens from hitherto unknown hosts, or with ascospores differing from those of known species on a particular host, are likely candidates for new species.

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Pertusaria wui sp. nov. on bamboo from Yunnan, China

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Abstract—A new species *Pertusaria wui* is described from bamboo in Yunnan Province, China. Diagnostic characters include a thin, shiny, off-white, continuous and crustose thallus, numerous (mostly conical) verrucae with punctiform ostioles, uniseriate ascospores of 47.5–62.5 × 25–30 µm, 8-spored asci, and major lichen compounds lichexanthone and stictic acid.

Key words—lichenized *Ascomycota*, *Pertusariaceae*, *Pertusariales*, taxonomy

Introduction

After molecular and allied data by Lumbsch & Schmitt (2001) indicated that *Pertusaria* DC. s.lat. was polyphyletic, Schmitt & Lumbsch (2004) identified three well-supported clades: /*Pertusaria* s.str., /*Varicellaria,* and /*Variolaria*. Archer & Elix (2016) divided *Pertusaria* DC. s.lat. into three subgenera, *P.* subg. *Monomurata* A.W. Archer, *P.* subg. *Pionospora* Th. Fr., and *P.* subg. *Pertusaria* based on morphological and chemical characters. However, the molecularly supported clades were elevated to the genera as *Pertusaria* DC. s.str., *Varicellaria* Nyl., and *Lepra* Scop. (Schmitt & al. 2012; Hafellner & Türk 2016; Wei & al. 2017), genera currently accepted by lichenologists (Archer & Elix 2018; Zhou & Ren 2018; Ren 2019). *Pertusaria* s.lat. in China was first annotated by Zhao & al. (2004), additional new taxa and new records have been published (Ren & al. 2008, 2009a,b; Ren & Kou 2013; Ren 2013, 2014, 2015; Ren & Zhao 2014; Zhang & Ren 2016). As part of a continuing study of *Pertusaria* s.str. from

China, we re-examined previously unidentified specimens to discover that a single KUN specimen represented a new species, described here as *Pertusaria wui*.

Materials & methods

The examined specimen is deposited in the Herbarium, Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China (KUN). It was examined microscopically under an Olympus SZX16 dissecting microscope and a Zeiss Axioskop 2+ compound microscope; chemical substances were identified by thin-layer chromatography using solvents A, B, and C (Elix 2014) and compared with authentic samples. We photographed the specimen with a Nikon D700 fitted with a Micro-Nikkor 105 mm f/2.8G AF-S VR IF-ED lens.

Taxonomy

Pertusaria wui Q. Ren, **sp. nov.** FIG. 1

FN 570761

Differs from *Pertusaria tetrathalamia* by its 8-spored asci and its lack of 4,5-dichlorolichexanthone.

TYPE—China. Yunnan Province, Nanjian County, Mt. Dadian, 24.85°N 100.57°E, on bamboo, 21 Mar. 2012, L.S. Wang 12-32980, X.Y. Wang & D. Liu (**Holotype**, KUN).

ETYMOLOGY—honoring the late Prof. Jinong Wu, who contributed greatly to Chinese lichen research.

THALLUS off-white, thin; surface smooth, shiny, continuous, lacking isidia and soredia. APOTHECIA conspicuous, concolorous with thallus, numerous, verruciform, frequently conical and smooth, generally dispersed and only locally fused, 0.5–0.8(–1.5) mm in diameter. Ostioles conspicuous, black, punctiform, 1–3(–5) per verruca, surrounded by a white border, mostly level with verruca surface but occasionally papillate. ASCOSPORES 8 per ascus, longitudinally uniseriate, hyaline, ellipsoid, 47.5–62.5 × 25–30 µm; ascospore wall smooth, c. 5 µm thick except for thicker (c. 10 µm) end wall. PYCNIDIA not observed.

CHEMISTRY—Cortex UV+ yellow-orange, all chemical tests negative. Medulla K+ yellow, C–, KC–, Pd+ yellow, then orange. Lichexanthone and stictic acid detected.

DISTRIBUTION—Currently known only from the type locality in Yunnan.

COMMENTS—*Pertusaria wui* is characterized by the numerous conical verrucae, asci with 8 uniseriate smooth-walled ascospores, and the presence of lichexanthone and stictic acid. The new species closely resembles *P. tetrathalamia* (Fée) Nyl. from North America and China (Dibben 1980;

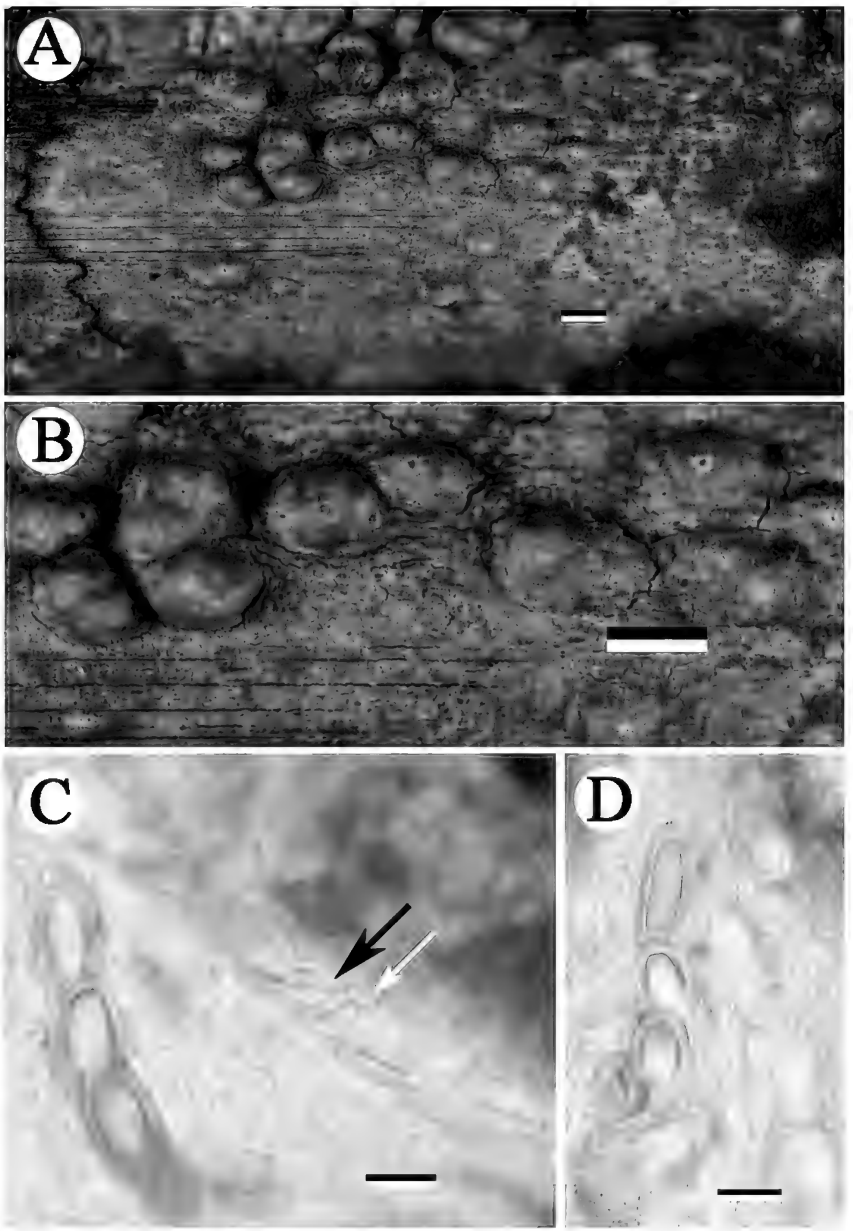

Fig. 1. *Pertusaria wui* (KUN – Wang 12-32980). A. Thallus with substratum; B. Apothecia, detail; C. Asci with mature or immature ascospores, arrows pointing to eight uniseriate and immature ascospores within one ascus; D. Mature ascospores. Scale bars: A, B = 1 mm; C, D = 30 µm.

Zhao & al. 2004) in also presenting conspicuous black ostioles and mostly simple verrucae, but *P. tetrathalamia* has 4-spored asci and contains stictic acid and 4,5-dichlorolichexanthone.

Beside the new species, only four other *Pertusaria* species possess 8-spored asci and contain lichexanthone and stictic acid as major lichen substances. Among them, *Pertusaria nigrata* Kremp. from Brazil (Krempelhuber 1876) and Sri Lanka (Weerakoon & Aptroot 2014) is most similar to the new species but differs in having longer ascospores (75–90 µm). The other three species are *P. dehiscens* Müll. Arg., *P. fosseyae* A.W. Archer & al., and *P. parnassia* Vain. Their differences from *P. wui* are indicated in the key below.

Key to *Pertusaria* spp. having 8-spored asci and lichexanthone + stictic acid as major lichen substances

1. Thallus sorediate (spores 2-seriate, 98–111 µm long);
   Kahuzi & Virunga mountain ranges in East Africa's Albertine Rift ... *P. fosseyae*
1. Thallus esorediate 2
2. Spore walls rough (spores 110–180 µm long);
   Guadeloupe, West Indies ..... *P. parnassia*
2. Spore walls smooth 3
3. Spores 2-seriate (90–140 µm long);
   Australia, Brazil, Chile, India, Sri Lanka ..... *P. dehiscens*
3. Spores 1-seriate 4
4. Spores 75–90 µm long (Brazil & Sri Lanka) ..... *P. nigrata*
4. Spores 47.5–62.5 µm long (China) ..... *P. wui*

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Clavaria cystidiata sp. nov. from India

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Abstract—A new species, *Clavaria cystidiata*, was collected and described from Kerala State, India. The species is proposed as new based on morphological and molecular evidence. *Clavaria cystidiata* differs from other closely related *Clavaria* species by its garlic smell, yellowish basidiomata, clamp connections at the base of basidia, and by the prominent presence of versiform cystidia. Sequence analyses of the nuclear rDNA internal transcribed spacer (ITS) region supports phylogenetic separation of *C. cystidiata* within *Clavariaceae*.

Keywords—*Agaricomycetes*, alliaceous, biodiversity, *Agaricales,* coral fungi

Introduction

Clavaria Vaill. is a basidiomycetous genus, comprising about 178 described species (Roskov & al. 2020). The genus has a cosmopolitan distribution. Representatives grow primarily as saprobes and (exceptionally) as associates of soil algae and ericoid plants (Corner 1950; Englander & Hull 1980, Olariaga & al. 2015). Basidiomata are simple (rarely branched), cylindrical to club shaped, and whitish, yellow, orange, pink, violet, or brown to black in color. Holobasidia bear hyaline spores. Characteristics of the basidia, hyphae, and presence and location of clamp connections have been used in infrageneric classifications.

Basidiomatal color has been used both as a key taxonomic character for delimiting species and informally grouping species within the genus (Corner 1950, 1970; Knudsen 1997; Petersen 1978, 1988; Roberts 2007; Kautmanová & al. 2012). Kautmanová & al. (2012) analyzed the phylogeny of dark *Clavaria* species (with grey, brown, and black basidiomata) using LSU nrDNA sequence data. Olariaga & al. (2015) studied yellow *Clavaria* species with clamped basidia

and inferred species relationships based on ITS and LSU nrDNA sequence analyses.

Similarly, the distinctive smell of basidiomata has served as a distinguishing taxonomic character in the genus. Basidiomata of some *Clavaria* species are known to emit a distinctive alliaceous smell, and Petersen (1988) used garlic smell as one identifying character in his keys to the New Zealand clavarioid species. *Clavaria falcata* Pers., *C. foetida* G.F. Atk., *C. fuscata* Oudem., and *C. redoleoalii* R.H. Petersen are the four known garlic-smelling species of *Clavaria*.

During an exploratory survey of the clavarioid fungi of Kerala, India, we encountered basidiomata of a garlic-smelling yellowish clavarioid fungus. Detailed examination revealed this collection as unique from all other described *Clavaria* species. Details of our morphological and molecular examination accompany the proposal of a new species. A key to *Clavaria* species reported from India is also provided.

Materials & methods

Morphological characterization

Fruit bodies were collected from Kerala State, India, during August 2017. Fresh material was examined macroscopically and tested with $FeCl_3$ and KOH. Dried materials were examined microscopically and stained using aqueous solutions of 3% phloxine and 1% Congo red mounted in 5% aqueous KOH. Twenty basidiospores were measured to calculate dimensions, mean, and standard deviation for length and width, range of spore quotient (Q, length/width ratio) and its mean value (Q_m). Basidiospore reactivity to Melzer's reagent and cotton blue was noted. The holotype was deposited at the Central National Herbarium, Kolkata, West Bengal, India (CAL), and an isotype was deposited at the Zamorin's Guruvayurappan College Herbarium, Kozhikode, Kerala, India (ZGC).

Molecular characterization & phylogenetic analysis

Genomic DNA was extracted from dried basidiomata, using the procedure of Izumitsu & al. (2012). The ITS region was amplified by PCR using primers ITS1F and ITS4 (Gardes & Bruns 1993, White & al. 1990). PCR product was purified using ExoSAP-IT treatment and sequenced using BigDye Terminator v3.1. The newly generated sequence was deposited in GenBank (www.ncbi.nlm.nih.gov) with accession number MK751792.

The newly generated sequence was subjected to a BLAST search in the GenBank nucleotide database for finding taxa with close sequence similarity. A data matrix was constructed with the newly generated sequence and ITS sequences retrieved from GenBank of 47 representative sequences in *Clavariaceae* (Table 1). All *Clavaria* species with ITS sequences available in GenBank were included in the dataset.

Table 1. Taxon and GenBank accession numbers for the ITS sequences used in phylogenetic analyses.

Taxon	GenBank no.	Strain/Herbarium no.	Location
Clavaria acuta	AY228353	F14294	—
Clavaria amoenoides	MF972891	AMB018217	Italy
Clavaria argillacea	KC759438	K(M)126733	England
Clavaria asterospora	KC759440	BIO-Fungi 12390	Spain
Clavaria atrofusca	HQ606080	BRACR 13264	Norway
Clavaria calabrica	MF972889	ZT Myc 58697	Italy
Clavaria californica	HQ179660	TENN:026785	USA
Clavaria citrinorubra	HQ179661	TENN:040464	Australia
Clavaria crosslandii	KC75944	BIO-Fungi 12762	Spain
Clavaria cystidiata	MK751792	CAL 1769	India
Clavaria falcata	KC759445	AB0532	Wales
Clavaria flavipes	KC759451	OJ362006	Austria
Clavaria flavostellifera	KC759462	BRACR16695	Spain
Clavaria fumosa	MK427065	Zp-2225	China
Clavaria fuscata	KP257128	TENN065665	USA
Clavaria greletii	MF503244	ERRO 2014102101	Spain
Clavaria greletoides	MF503243	ERRO 2009070701	Spain
Clavaria griseobrunnea	NR158336	12566	Spain
Clavaria incarnata	KC759452	BIO-Fungi 12560	Spain
Clavaria redoleoalii	MF664111	PDD105311	New Zealand
Clavaria rosea	MK909560	TUR 201239	Finland
Clavaria rubicundula	MK578690	6603126	USA
Clavaria sphagnicola	KC759456	BRNM 747282	Czechia
Clavaria tenuipes	KC759457	K(M)146565	England
Clavaria tyrrhenica	MF972890	ZT Myc 58698	Italy
Clavaria zollingeri	MH016820	FLAS-F-60642	USA
Clavicorona taxophila	AF033344	71850	—
Clavulinopsis amoena	MK427063	ZP-2400	China
Clavulinopsis cf. *helvola*	KT275650	SE-2015	USA
Clavulinopsis fusiformis	KM248914	2718	—
Clavulinopsis laeticolor	EU118618	EL 8/00	Finland
Clavulinopsis miyabeana	MK427059	ZP.2118	China
Clavulinopsis sulcata	MK427060	ZP-2119	China
Camarophyllopsis atrovelutina	KU882900	TL2014-682591	Denmark
Camarophyllopsis phaeophylla	MK139805	1ERRO 2013112901	France
Camarophyllopsis rugulosa	NR_119896	TENN 023664	USA
Camarophyllopsis atropuncta	HQ662165	4G4-2010	Ireland
Camarophyllopsis schulzeri	GU187556	GG091005	Wales
Hyphodontiella multiseptata	EU118634	Ryberg 021022 (GB)	Sweden
Mucronella sp.	HQ533013	PDD95742	New Zealand
Mucronella sp.	MH409972	strain 1214	New Zealand
Mucronella bresadolae	DQ384591.1	F15204	—
Ramariopsis flavescens	NR_119913	TENN 027570	USA
Ramariopsis kunzei	MK616542	AMB n. 17485	Italy
Ramariopsis crocea	MK607557	302989	USA
Ramariopsis pulchella	KX812470	MCCNNU00981	China
Scytinopogon havencampii	NR151488	SFSU DED8300	—

Scytinopogon havencampii Desjardin & B.A. Perry (*Hydnodontaceae, Trechisporales*) was chosen as the outgroup taxon following Birkebak & al. (2013). There were a total of 717 positions in the final dataset. The aligned nrITS data matrix [ID: 26259] was deposited in TreeBase. DNA sequences of the ITS dataset were aligned automatically with MUSCLE in MEGA (Kumar & al. 2018) and then manually edited using the same program.

Phylogenetic analyses were conducted using Maximum Likelihood (ML) and Bayesian analysis (BA) methods. ML analysis was done with Tamura-Nei model (Tamura & Nei 1993) in MEGA. Initial tree(s) for the heuristic search were obtained automatically by applying Neighbor-Join and BioNJ algorithms to a matrix of pair wise distances estimated using the Maximum Composite Likelihood (MCL) approach, and then selecting the topology with superior log likelihood value. The tree with the highest log likelihood value (–16331.38) was selected. The tree was drawn to scale, with branch lengths measured in the number of substitutions per site. BA was conducted using MrBayes 3.2 (Ronquist & al. 2012). Bayesian phylogenetic inference was done with a T92+G model with discrete gamma distributed substitution rates for the sequence dataset. The best-fit likelihood model of evolution was estimated in MEGA. Multiple independent analyses were run from random starting trees for four million generations, with trees saved every 100 generations, using four chains and a burnin fraction of 0.25.

Taxonomy

Clavaria cystidiata Krishnapriya & T.K.A. Kumar, **sp. nov.** FIGS 1, 2

MB 832680

Differs from other garlic-smelling, yellowish *Clavaria* spp. by its prominent versiform cystidia and its bi-sterigmate basidia with basal clamp connections.

TYPE: India, Kerala State, Kozhikode District, Madapally Govt. College Campus, 9.4698°N 76.5902°E, altitude 11 m, on soil, solitary and in gregarious clusters among dead and decaying leaf litter, 01 August 2017, K. Krishnapriya (**Holotype,** CAL 1769; **Isotype,** ZGCKP59; GenBank MK751792).

ETYMOLOGY: *cystidiata,* referring to the prominent cystidia, the primary distinguishing morphological character of the species.

BASIDIOMATA ≤110 mm long, ≤3 mm thick, simple, unbranched, cylindrical, solid when young becoming hollow with age; terete in cross section; apex acute, narrowing towards base; glabrous; off white to pale yellow when young, becoming yellowish when mature, dark yellow to pale orange towards the apex; context fleshy, with strong garlic odor; no positive reaction in $FeCl_3$ and KOH.

BASIDIOSPORES 7–10 × 5–8 µm (Q=1.1–1.5 µm, Q_m=1.2 µm), broadly ellipsoid, contents granulate and guttulate (primarily one single large oil droplet), smooth, thin-walled, hyaline, apiculus prominent (≤1 µm long), inamyloid, cyanophilic in cotton blue. BASIDIA 50–60 × 7–10 µm, aguttulate

Fig. 1. *Clavaria cystidiata* (holotype, CAL 1769): Basidiomata. Scale bar=10 μm.

to multiguttulate, cylindrical to clavate with basal clamp connection, sterigmata 1–2(≤5) μm long. Cystidia abundant, 21–75 × 10–21 μm, versiform (predominantly cylindrical, clavate, lageniform, broadly clavate), many with ≤27 μm long apical protrusions, thin-walled, inamyloid, hyaline.

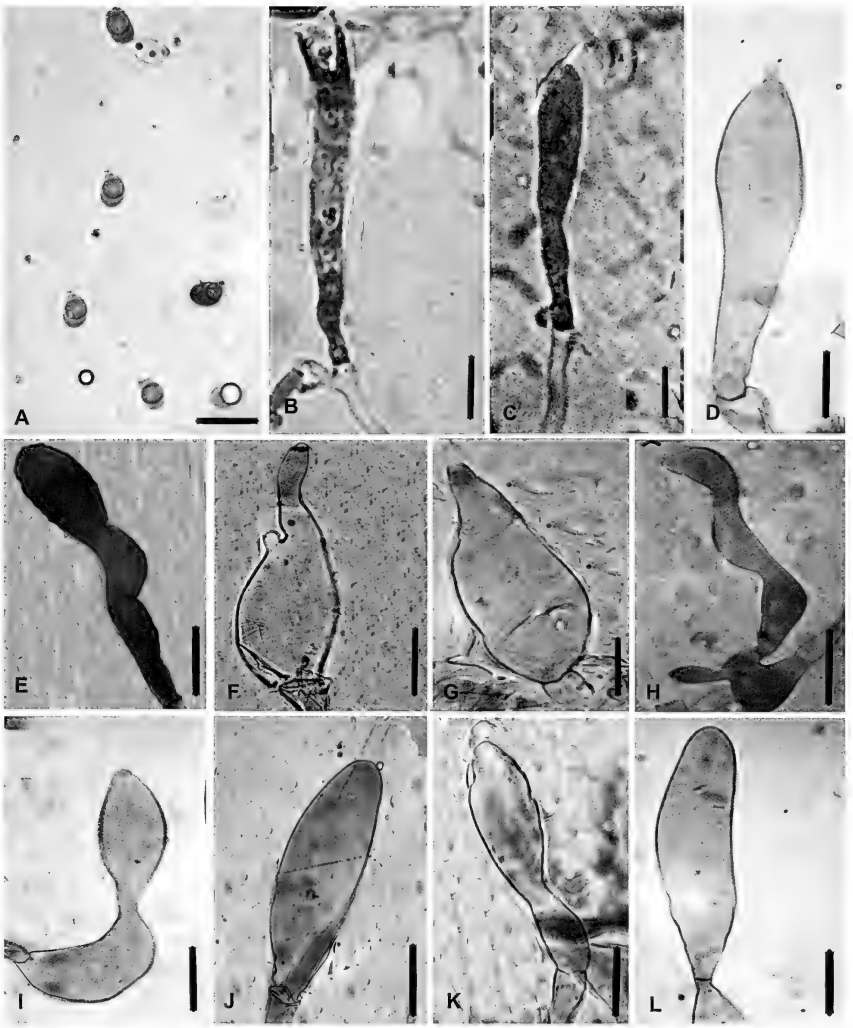


Fig. 2. *Clavaria cystidiata* (holotype, CAL 1769). A. Basidiospores; B. Basidium with sterigmata; C. Basidium with basal clamp connection; D–L. Cystidia. Scale bars: A, C= 8 µm; B, D–L=10 µm.

Hymenium 20–30 µm wide. Subhymenium 50–60 µm wide. Context hyphae parallel, septate, inflated, 3–25 µm wide, hyaline to pale yellow, thin- to slightly thick-walled (≤1 µm), cyanophilic, inamyloid. Hyphal clamp connections absent.

Ecology & distribution: On soil. Both solitary and in gregarious groups among leaf litter.

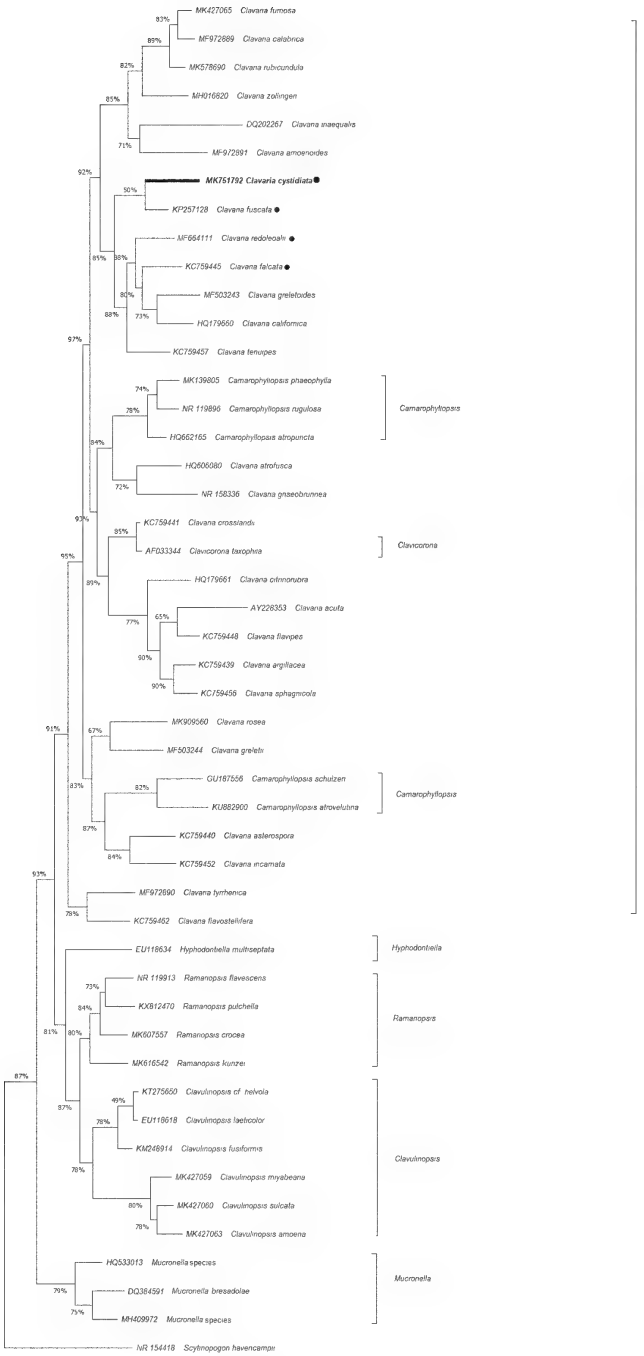
Molecular analysis

Sequencing of ITS region of the specimen of *Clavaria cystidiata* yielded 633 base pairs. The GenBank BLAST search of this newly generated sequence produced sequence identities of only 83% with *C. fuscata*, 80% with *C. falcata,* and 79% with *C. redoleoalii*, the closest BLAST hits. The ML (Fig 3) and BA (Fig 4) phylogenetic trees were congruent with respect to the majority of clades and taxa. *Clavaria cystidiata* clustered in a clade with the three garlic-smelling taxa (*C. fuscata, C. redoleoalii, C. falcata*) and three non-garlic-smelling species (*C. greletoides, C. californica, C. tenuipes*) with 85% ML bootstrap support (BS), and 0.86 BA posterior probability (PP) support. The new species, *C. cystidiata* resolved as sister to *C. fuscata*, receiving low (50% BS) value in the ML tree but strong (PP 1) support in the BA tree. The yellow-coloured *Clavaria* species included in the analyses—*C. amoenoides* Corner & al., *C. argillacea* Pers., *C. citrinorubra* R.H. Petersen, *C. flavipes* Pers., *C. flavostellifera* Olariaga & al., *C. inaequalis* (Pers.) Corner, *C. sphagnicola* Boud., *C. redoleoalii*—did not form a monophyletic group. The monotypic *Clavicorona taxophila* (Thom) Doty clustered with *Clavaria crosslandii* Cotton (84% BS, 0.94 PP). *Camarophyllopsis* species included in the study were recovered in two separate clades in both Bayesian and ML analyses. *Hyphodontiella multiseptata* Å. Strid fell into a sister clade to *Ramariopsis* and *Clavulinopsis*, forming a well-supported monophyletic group, distinct from the *Clavaria–Camarophyllopsis–Clavicorona* clade in the ML analysis. In the BA analysis, *H. multiseptata* fell into the *Ramariopsis* clade. *Mucronella* forms a distinct clade from the rest (79% BS, 0.84 PP).

Discussion

Clavaria cystidiata is recognized by its yellowish colour, strong garlic smell, basal clamp connection in basidia, presence of cystidia, large spores, and inflated hyphae. The presence of strong garlic odor and prominent cystidia are key characters which differentiate *C. cystidiata* from other yellow coloured *Clavaria* species. Corner & al. (1956) proposed a yellow *Clavaria* species, *C. amoenoides* from India. Its yellow colored basidiomata show similarity with *C. cystidiata* macroscopically but the absence of clamp connection at the base of basidia, absence of cystidia, and the absence of garlic odor (Thind 1961) makes it different.

Clavaria cystidiata closely resembles *C. fuscata*, *C. foetida, C. redoleoalii,* and *C. falcata* morphologically (Table 2). During BLAST search in NCBI's GenBank nucleotide database *C. cystidiata* shows only 83% similarity with *C. fuscata.* Morphologically *C. fuscata* differs from *C. cystidiata* in having white coloured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MF972889 Clavaria calabrica
MK578690 Clavaria rubricundula
MH016820 Clavaria zollingeri
DQ202267 Clavaria snaequalis
MF972891 Clavaria amoenoides
MK751792 Clavaria cystidiata
KP257128 Clavaria fuscata
MF664111 Clavaria redolens
KC759445 Clavaria falcata
MF503243 Clavaria greletoides
HQ179650 Clavaria californica
KC759457 Clavaria fenuipes
MK139805 Camarophytopsis phaeophylla
NR 119896 Camarophyllopsis rugulosa
HQ662165 Camarophyllopsis atropuncta
HQ606080 Clavaria atrofusca
NR 156336 Clavaria gnaeobrunnea
KC759441 Clavaria crosslandii
AF033344 Clavicorona taxophila
HQ179661 Clavaria crinnonupra
AY226353 Clavaria acuta
KC759448 Clavaria flavipes
KC759439 Clavaria argillacea
KC759456 Clavaria sphagnicola
MK909960 Clavaria rosea
MF503244 Clavaria greletii
GU187556 Camarophyllopsis schulzeri
KU882900 Camarophyllopsis atrovelutina
KC759440 Clavaria asterospora
KC759452 Clavaria incarnata
MF972890 Clavaria tyrrhenica
KC759462 Clavaria flavostellifera
EU118634 Hyphodontiella multiseptata
NR 119913 Ramariopsis flavescens
KX812470 Ramariopsis pulchella
MK607557 Ramariopsis crocea
MK616542 Ramariopsis kunzei
KT275650 Clavulinopsis cf. helvola
EU118618 Clavulinopsis laeticolor
KM246914 Clavulinopsis fusiformis
MK427059 Clavulinopsis miyabeana
MK427060 Clavulinopsis sulcata
MK427063 Clavulinopsis amoena
HQ533013 Mucronella species
DQ384591 Mucronella bresadolae
MH409972 Mucronella species
NR 154418 Scytinopogon havencampii
Camarophytopsis
Clavicorona
Camarophyllopsis
Hyphodontiella
Ramariopsis
Clavulinopsis
Mucronella
Clavaria

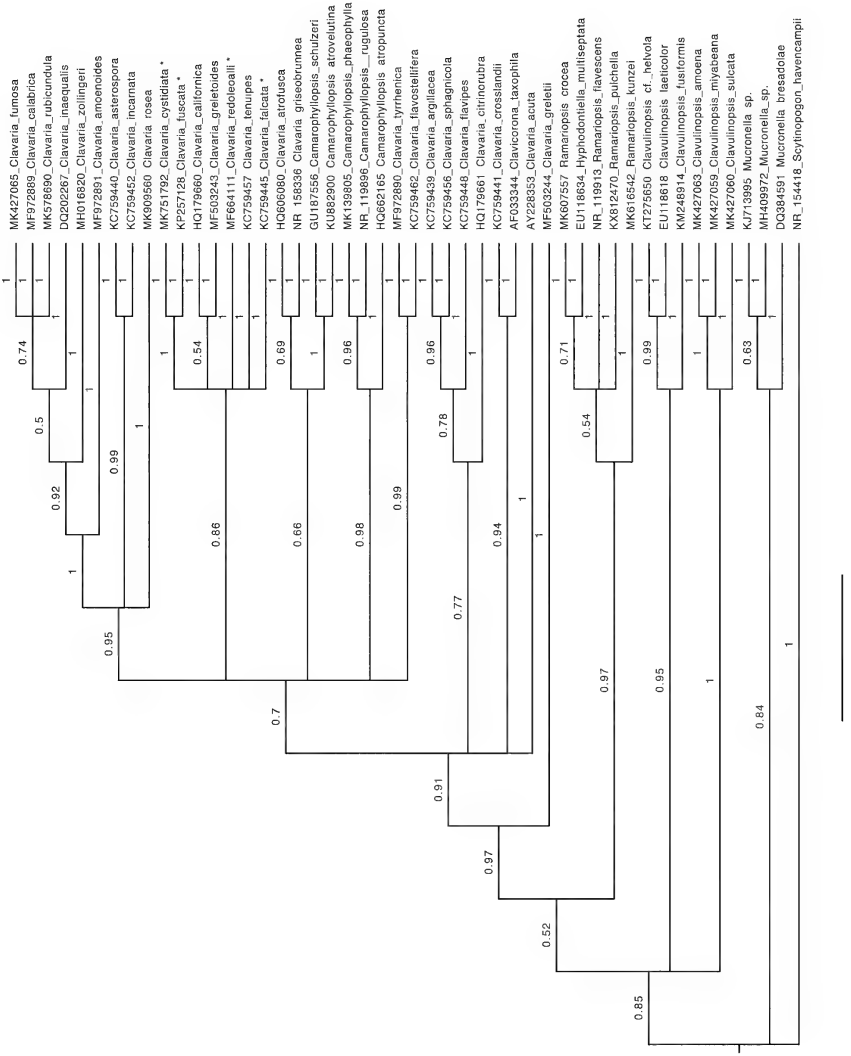

FIG. 3 (left). Maximum likelihood tree showing phylogenetic placement of *Clavaria cystidiata* (shown in bold and with a thickened branch). ML BS values are shown. Sequences are identified by GenBank accession number.

FIG. 4 (above). Bayesian analysis consensus tree for *Clavaria cystidiata* and related taxa, with PP values shown on the branches. Four garlic-smelling species are indicated with asterisks. Sequences are identified by GenBank accession number.

Table 2. Morphological comparison between *Clavaria cystidiata* and other garlic-smelling *Clavaria* spp.

	C. cystidiata	*C. falcata*	*C. foetida*	*C. fuscata*	*C. redoleoalii*
Basidiome color	Pale yellow to yellow	White to cream	Maize yellow	White	White
Hyphal diam (µm)	3–4µm, inflated ≤25	—	6–20	3.5–12	4–12
Cystidia	Present	Absent	Absent	Absent	Absent
Spore size (µm)	7–10 × 5–8	7–12 × 4–9	5.4–7.2 × 3.2–4.0	8–10 × 4.5–6	6.1–7.6 × 5.4–6.5
Basidial clamp	Present	Absent	Absent	Absent	Present
Sterigmata	2	4	4	2	4
Range	Tropical	Tropical & Temperate	Temperate	Temperate	Temperate

basidiomata, absence of basal basidial clamp connections and cystidia, and very small basidia (22–30 µm, Corner 1950). According to Coker (1923), the spore size of *C. fuscata* ranges from 4.4–6 × 8–10 µm. The color of the fruit body and strong garlic odor of *C. foetida* is similar to that of *C. cystidiata*. But spore size (5.4–7.2 × 3.2–4.0 µm), presence of four sterigmata, absence of cystidia, and absence of basal clamp connections of basidia in *C. foetida* (Petersen 1988) separates the two. Unfortunately, *C. foetida* was unavailable for DNA extraction and sequencing for our molecular analyses, as the use of the only known and available single basidiomata of the species deposited in a public herbarium was restricted. Hence, this garlic-smelling taxon could not be included in this study. *C. redoleoalii* is a garlic-smelling *Clavaria*, having abundant crystalline material in tramal hyphae, with secondary septations and four sterigmata (Petersen 1988). *C. redoleoalii* also lacks cystidia. These characters differentiate *C. cystidiata* from *C. redoleoalii*. Sequence of *C. redoleoalii* showed only 79% similarity with *C. cystidiata* during the BLAST search. Another garlic-smelling taxon, *C. falcata* showed only 80% sequence similarity with *C. cystidiata*. Morphologically, it differs from *C. cystidiata* in having white to cream colored basidiomata, absence of basidial clamp connections, presence of four-spored basidia, and absence of cystidia. *C. cystidiata* is unique from all the described species of *Clavaria* by the presence of its prominent versiform cystidia.

Out of the eight *Clavaria* species described so far with yellowish basidiomata, only one species (*C. amoenoides*) has previously been reported from India (Verma & Pandro 2018). The phylogeny of yellow *Clavaria* species has been studied before. Molecular investigations (Olariaga & al. 2015; Birkebak & al. 2013, 2016) had proved that they do not form a monophyletic group. Our ML and BA studies also support these observations. *C. cystidiata* now ranks as the fifth garlic-smelling species of *Clavaria* to be collected and reported globally. There are no reports of garlic-smelling *Clavaria* species from India to date. Interestingly, our molecular analyses (ML and BA) recovered all taxa with garlic-smelling basidiomata together as a separate group. However, three non-garlic-smelling taxa also are settled in this group. Phylogenetic placement of all other taxa of *Clavariaceae*, included in our analyses, conforms to the results of previous studies (Birkebak & al. 2013, 2016; Olariaga & al. 2015). Our morphological studies and molecular analyses reveal the distinction and phylogenetic placement of *C. cystidiata* within the *Clavariaceae*. Based on these data, we propose the species as new to science.

Key to the *Clavaria* species from India

1. Basidiomata branched 2
1. Basidiomata unbranched 3

2. Basidiomata purple to pinkish purple; frequent to occasional branching *C. zollingeri*
2. Basidiomata white; always with crowded branches ..... *C. jacquemontii*

3. Loop-like clamp connections present at basidial bases 4
3. Loop-like clamp connections absent from basidial bases 5

4. Basidiomata with garlic odor ..... *C. cystidiata*
4. Basidiomata without garlic odor *6*

5. Basidiomata yellow ..... *C. amoenoides*
5. Basidiomata not yellow; brown, white, or grey 7

6. Basidiomata pink; basidiospores 6–7.5 × 4–4.5 µm, ellipsoid; hyphae not secondarily septate ..... *C. incarnata*
6. Basidiomata white; basidiospores 8–11 × 6–8 µm, globose; hyphae secondarily septate ..... *C. acuta*

7. Basidiomata brown; basidiospores 5.5–7.5 × 2.5–3.2 µm; basidia 25–40 × 5.5–8 µm; hyphae 2–13 µm diam ..... *C. indica*
7. Basidiomata white or grey 8

8. Basidiomata grey 9
8. Basidiomata white 10

9. Hyphae inflated 11
9. Hyphae not inflated;
basidiospores 4–4.5 × 3–5 µm, subovoid, slightly fuscous ..... *C. gollanii*
10. Basidiomata 6.5–8 cm high; basidiospores 3.3–3.7 × 5–7.4 µm,
ellipsoid, convex on one side; hyphae not inflated, 3–7 µm diam ..... *C. cretacea*
10. Basidiomata 3–10 cm high; basidiospores 4.8–6.2 × 3.1–3.9 µm,
not ellipsoid, pyriform; hyphae 2–3 µm diam ..... *C. fragilis*
11. Basidiomata 2–3 cm high; basidiospores 4–6 × 2.5–3.5 µm,
pyriform; hyphae 15–18 µm diam ..... *C. crosslandii*
11. Basidiomata 12 cm high; basidiospores 7–8 × 2.8–6.3 µm,
subcylindric; hyphae 17 µm diam ..... *C. fumosa*

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Aspicilia lixianensis, A. nivalis, and *A. pycnocarpa* spp. nov. from China

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Abstract — As a result of our study of *Aspicilia* from China, three new lichen species—*A. lixianensis*, *A. nivalis*, and *A. pycnocarpa*—are proposed and typified. Detailed descriptions, comparisons with related species, morphological photographs, and phylogenetic analysis of these taxa are provided.

Key words — ITS, *Megasporaceae*, *Pertusariales,* secondary metabolites, taxonomy

Introduction

Aspicilia A. Massal. is a large genus containing ca. 200 species (Lücking & al. 2016). Since being established by Massalongo in 1852, its taxonomic status has been very vague. It was long treated as a section of *Lecanora* Ach. (*Lecanoraceae*) for a long time (Magnusson 1940, 1952; Zahlbruckner 1930), until Hafellner (1984) restored *Aspicilia* to genus rank. Based on their three-gene phylogenetic analysis, Lumbsch & al. (2007) placed *Aspicilia* in *Megasporaceae.*

The main characteristics of *Aspicilia* are thallus crustose, rimose to areolate, prothallus present or not (if present, sometimes peripherally radiate or zonate); apothecia lecanorine, usually immersed, disk usually concave; epihymenium olive-green or dark brown and turning green with HNO_3; paraphyses usually moniliform or submoniliform; 8-spored asci;

Table 1. ITS sequences used in the phylogenetic analysis.
Newly generated sequences are in bold.

Species	GenBank	Species	GenBank
Aspicilia blastidiata	KX129963	*Aspicilia rivulicola*	EU057922
Aspicilia cinerea	MN906262	*Aspicilia subepiglypta*	KY249608
Aspicilia dendroplaca	HQ259260	*Aspicilia subgeographica*	KY249612
Aspicilia dudinensis	EU057906	*Aspicilia subgoettweigensis*	KY249614
Aspicilia goettweigensis	KX159293	*Aspicilia supertegens*	EU057938
Aspicilia lixianensis	**MW174005**	*Aspicilia virginea*	HQ259271
Aspicilia mashiginensis	EU057912	*Aspicilia volcanica*	NR158307
Aspicilia nivalis	**MW174002**		
Aspicilia permutata	EU057920	*Lobothallia crassimarginata*	JX476026
Aspicilia pycnocarpa	**MW174004**	*Lobothallia pruinosa*	JX476028

simple, colorless, and often ellipsoid ascospores (Owe-Larsson & al. 2007). *Aspicilia* species, which grow primarily on siliceous or calcareous rocks, are widely distributed throughout the world.

Forty species of *Aspicilia* have been reported in China (Hou & al. 2014, Ismayil & al. 2015, Li & al. 2013, Magnusson 1940, Shavkat & al. 2019, Zahlbruckner 1930), but many specimens in Chinese herbaria remain unidentified. After examining several specimen loans, we identified three *Aspicilia* species new to science, described in this paper.

Materials & methods

The specimens examined were deposited in Herbarium Mycologicum Academiae Sciences-Lichenes, Chinese Academy of Sciences, Beijing, China (HMAS-L) and the Plant Herbarium of Shandong Normal University, Jinan, China (SDNU).

DNA extraction, PCR amplification, sequencing

DNA was extracted from the specimens using CTAB method. The isolated DNA was amplified using primers ITS1F (Gardes & Bruns 1993) and ITS4 (White & al. 1990). Each 25 µL sample contained 5.5 µL distilled H_2O, 5 µL DNA dilution, 1 µL of each primer, and 12.5 µL CWBio 0690 2xEs Taq MasterMix (Dye). The PCR mixture underwent a 5-minute initial denaturation at 95 °C, five cycles comprising 30 seconds at 95 °C + 30 seconds at 58 °C + 1 minute at 72 °C followed by 30–35 cycles with the

annealing temperature decreased from 58 to 56 °C and concluded with final 7-minute extension at 72 °C (Sohrabi & al. 2013). PCR products were sequenced by BioSune Biotech Co. Ltd. in Beijing.

Phylogenetic analysis

We aligned three newly obtained ITS sequences with 14 ITS sequences belonging to *Aspicilia* and two *Lobothallia* sequences as the outgroup downloaded from GenBank (Table 1) using ClustalW in MEGA7 and optimized manually. A phylogeny was inferred by the Maximum Likelihood (ML) method based on the General Time Reversible model and Gamma Distributed in MEGA7 (Kumar & al. 2016).

Morphology and chemistry

We examined the morphology using a stereo microscope and a light microscope. The lichen products were detected by color reaction tests (CT) and thin-layer chromatography (TLC) using solvent systems A, B, and C (Elix 2014). The CT

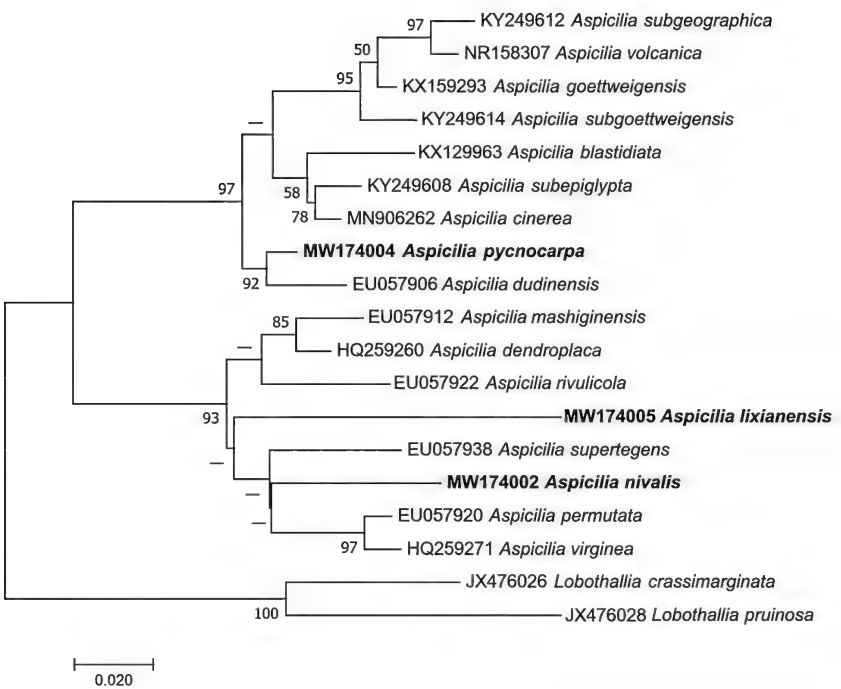

Fig. 1. The most parsimonious ML tree generated from ITS sequences showing the phylogenetic placement of *Aspicilia pycnocarpa, A. lixianensis,* and *A. nivalis* (in bold) among 17 *Aspicilia* spp. and two *Lobothallia* spp. (outgroup). Bootstrap probabilities (50–100%) are indicated at internal branches.

reagents used were K (10% KOH in water), N (50% nitric acid), and IKI (Lugol's iodine solution).

ITS sequence analysis

Phylogenetic analysis produced a parsimonious tree with 50–100% bootstrap support values (Fig. 1). All *Aspicilia* species clustered within one monophyletic clade with the ITS sequence analysis supporting *Aspicilia pycnocarpa*, *A. lixianensis,* and *A. nivalis* as separate taxa. *Aspicilia pycnocarpa* appears to be closely related to *Aspicilia dudinensis*. *Aspicilia lixianensis* and *A. nivalis* are on separate branches, and no close relationships are indicated by the analysis.

Taxonomy

Aspicilia pycnocarpa Q. Ren & Lin Liu, **sp. nov.** Fig. 2

FN 570766

Differs from *Aspicilia cinerea* by its longer conidia and possession of stictic acid as its major lichen product.

Type: China, Jilin Province, route from Changbai County to Tianchi south slope scenic area, alt. 1300 m, on siliceous rock, 25 Jul. 2014, L. Hu 20141380 (**Holotype**, SDNU; GenBank MW174004).

Etymology: from the Greek elements *pycno-* (crowded) + *-carpa* (fruit), referring to its abundant apothecia.

Thallus crustose, areolate to rimose, 2.5–4.5 cm diam., 0.1–0.3 mm thick, pale brown to brown; areoles irregular, 0.2–1 mm diam., flat, continuous, fissured, cracks deep; prothallus inconspicuous. Upper cortex 25–30 μm thick, epruinose. Algal layer 20–30(–37.5) μm thick.

Apothecia prominent, abundant, aspicilioid, 1(–4) per areole, 0.1–0.7 mm diam.; disc brown to black, flat to slightly concave, epruinose, or sometimes slightly pruinose; thalline margin inconspicuous. True exciple to 37.5–62.5 *μ*m wide in lateral portion. Epihymenium olive-green to olive-brown, K+ brown, N+ green; Hymenium hyaline, IKI+ blue, 87.5–112.5 μm high; paraphyses not separating in KOH, distinctly moniliform with 2–6 globular cells; hypothecium colorless, IKI+ blue, 50–75 μm thick, with algae below the hypothecium. Asci clavate, *Aspicilia*-type, 8-spored; ascospores hyaline, simple, ellipsoid, (12.5–)17.5–21.25 × (8.75–)10–12.5 μm. Pycnidia black, round-shaped; conidia filiform, straight or slightly curved, (13.75–)17.5–25(–27.5) μm long.

Spot tests—Upper cortex K+ yellow, sometimes turning red or orange; medulla K+ yellow.

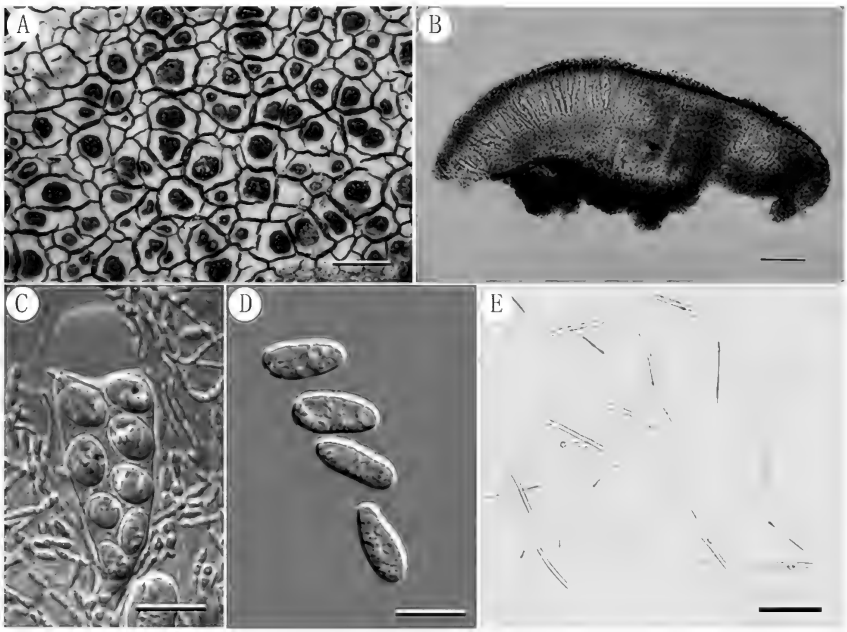

Fig. 2. *Aspicilia pycnocarpa* (holotype, SDNU 20141380). A. Thallus with apothecia; B. Apothecial section; C. Ascus with 8 ascospores; D. Ascospores: colorless, simple, ellipsoid; E. Filiform conidia. Scale bars: A = 1 mm; B = 100 μm; C–E = 20 μm.

Secondary metabolites—Stictic acid (major), norstictic acid (minor) and substictic acid (minor) (TLC).

Ecology—On siliceous rock, interspersed with other lichens, such as *Lecidea* sp. Known only from the type locality.

Additional specimen examined—**China. Jilin Province:** route from Changbai County to Tianchi south slope scenic area, alt. 1300 m, on siliceous rock, 25 Jul. 2014, L. Hu 20141379 (SDNU).

Comments—*Aspicilia pycnocarpa* is characterized by its thin flat thallus, flat to slightly elevated thalline margin, abundant apothecia, medium ascospores, and long conidia. The specimens in SDNU were previously identified as *A. cinerea* (L.) Körb. based on the presence of norstictic acid, but *A. cinerea* has shorter conidia (11–16 μm) and contains mainly norstictic acid (Owe-Larsson & al. 2007). *Aspicilia pycnocarpa* is similar to *A. pacifica* Owe-Larss. & A. Nordin, which is distinguished by its higher hymenium (130–220 μm), larger ascospores (14–33 × 10–20 μm), and shorter conidia (8–17 μm) (Owe-Larsson & al. 2007).

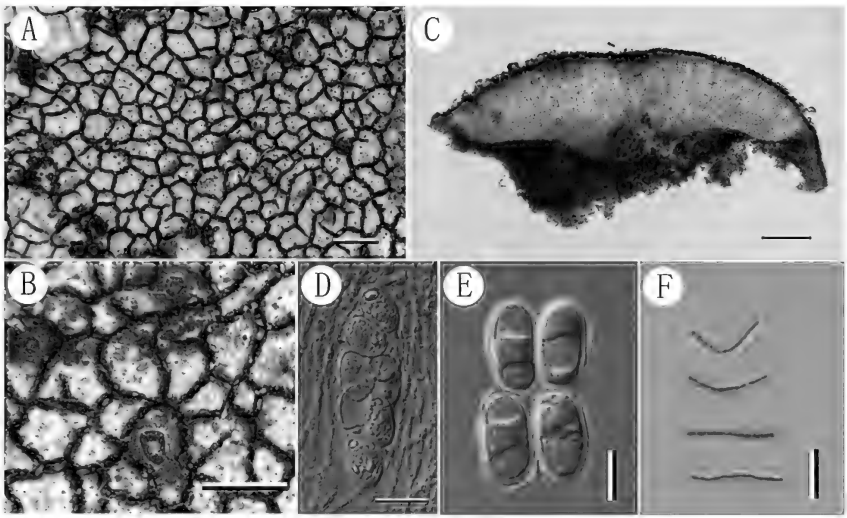

Fig. 3. *Aspicilia lixianensis* (holotype, HMAS-L 0139004). A. Thallus in moist environment; B. Thallus with apothecia; C. Apothecial section; D. Ascus with 8 ascospores; E. Ascospores: colorless, simple, ellipsoid; F. Filiform conidia. Scale bars: A = 2 mm; B = 0.5 mm; C = 100 μm; D = 20 μm; E, F = 10 μm.

In the ML-tree, *A. pycnocarpa* appears closely related to *A. dudinensis* (H. Magn.) Oxner, which differs by its usually disjointed pale or dark gray areoles, smaller ascospores (15–18 × 8.5–10 μm), and 18–22 μm long conidia (Magnusson 1952, as *Lecanora dudinensis*).

Aspicilia lixianensis Q. Ren & Lin Liu, **sp. nov.** Fig. 3

FN 570763

Differs from *Aspicilia asiatica* by its higher hymenium, from *Aspicilia subconfluens* by its lower hypothecium, and from both by its siliceous substrate.

Type: China, Sichuan Province, Lixian County, roadside of Jiabigou, 31.621 31.6214°N 1028455°E, alt. 2950 m, on siliceous rock, 10 Aug. 2016, W.C. Wang, WWC-51 (**Holotype**, HMAS-L 0139004; GenBank MW174005).

Etymology: referring to its type locality, Lixian County in Sichuan Province.

Thallus crustose, areolate to rimose, 0.5–1.5 cm diam., ±0.3 mm thick, gray to dark gray; areoles irregular, 0.2–1 mm diam., flat or slightly convex, continuous, fissured, cracks deep; prothallus inconspicuous. Upper cortex 12.5–25 μm thick, densely pruinose. Algal layer 37.5–50 μm thick.

Apothecia prominent, aspicilioid, usually solitary in the areoles, 0.25–0.7 mm diam.; disc black, flat to slightly convex, with dense white pruina

in center; thalline margin usually inconspicuous. True exciple inconspicuous. Epihymenium olive-brown, K+ brown, N+ green; hymenium hyaline, IKI+ blue, 125–167.5 μm high; paraphyses separating in KOH, distinctly moniliform with 4–6 globular cells; hypothecium colorless, IKI+ blue, 37.5–87.5 μm thick, with algae below the hypothecium. Asci clavate, *Aspicilia*-type, 8-spored; ascospores hyaline, simple, ellipsoid, (10–)12.5–17.5(–20) × (6.25–)8.75–12.5 μm. Pycnidia black, stellate-shaped; conidia filiform, straight or curved, (10–)15–20 μm long.

Spot tests—Upper cortex K+ pale yellow; medulla K+ yellow.

Secondary metabolites—Stictic acid (major), substictic acid (minor) (TLC).

Ecology—On siliceous rock, growing with *A. cinerea*. Known only from the type locality.

Comments—*Aspicilia lixianensis* is characterized by its dark gray upper surface with white pruina, black disks covered by densely white pruina, medium ascospores and conidia, and the presence of stictic and substictic acids. This specimen had few apothecia and abundant pycnidia and was surrounded by *A. cinerea*.

Morphologically, *A. lixianensis* resembles *A. asiatica* (H. Magn.) Yoshim. and *A. subconfluens* (H. Magn.) J.C. Wei, but those two species grow on slightly calciferous rocks in arid and semi-arid areas. Additionally, *A. asiatica* has lower hymenium (85–100 μm) (Magnusson 1940, as *Lecanora asiatica*) while the hypothecium of *A. subconfluens* is usually higher (150–200 μm; Magnusson 1940, as *Lecanora subconfluens*).

Aspicilia nivalis Q. Ren & Lin Liu, **sp. nov.** Fig. 4

FN 570764

Differs from *Aspicilia decorticata* by its white thallus, its higher hymenium, and its larger ascospores.

Type: China, Xizang, Jiangda County, Xuejila Mountain, 31.445°N 98.0547E, alt. 4300 m, on sandstone, 10 Aug. 2016, W.C. Wang, WWC-148 (**Holotype**, HMAS-L 0139012; GenBank MW174002).

Etymology: from *nivalis,* referring to the rough snow-white thallus and high elevation snow-covered (in winter) type locality on Xuejila Mountain.

Thallus crustose, areolate, 1–3.5 cm diam., ±0.5 mm thick, white; areoles irregular, 0.5–1.5 mm diam., flat, continuous, rough, slightly to deeply fissured; prothallus inconspicuous. Upper cortex 25–50 μm thick, powdery. Algal layer 50–62.5 μm thick.

Apothecia prominent, aspicilioid, 1(–3) per areole, 0.2–0.6 mm diam.; disc black, slightly concave, with dense white pruina; thalline margin conspicuous and flat, usually forming a black rim. True exciple inconspicuous. Epihymenium dark brown, K+ brown, N+ green; hymenium hyaline, IKI+ blue, 125–150 μm high; paraphyses separating in KOH, distinctly moniliform with 4–6 globular cells; hypothecium colorless, IKI+ blue, 25–45 μm thick, without algae below the hypothecium. Asci clavate, *Aspicilia*-type, 8-spored; ascospores hyaline, simple, ellipsoid, 18.75–30 × 10–15 μm. Pycnidia black, round-shaped; conidia filiform, straight or curved, 17.5–25 μm long.

Spot tests—Upper cortex K–; medulla K–.

Secondary metabolite—Substictic acid (TLC).

Ecology—On red-brown sandstone. Known only from the type locality.

Comments—*Aspicilia nivalis* is characterized by its continuous and extremely rough thallus with powdery surface, large ascospores, and long conidia. It is similar to *A. decorticata* (H. Magn.) J.C. Wei, which differs by having a pale yellowish thallus, lower hymenium (85–100 μm), smaller ascospores (12–15 × 7.5–8.5 μm), and calciferous rock substrate (Magnusson 1940, as *Lecanora decorticata*). The new species is also similar to *A. persica* (Müll. Arg.) Sohrabi, which differs by growth on siliceous rock, densely pruinose upper cortex, shorter ascospores (17.5–22.5 μm), and different secondary metabolites (stictic acid, ±norstictic acid) (Li & al. 2013). *Aspicilia nivalis* also resembles *A. albocretacea* (Zahlbr.) J.C. Wei, separated by its continuous thallus with few cracks, epruinose discs, and shorter ascospores (19–23 μm; Zahlbruckner 1930, as *Lecanora albocretacea*).

Acknowledgements

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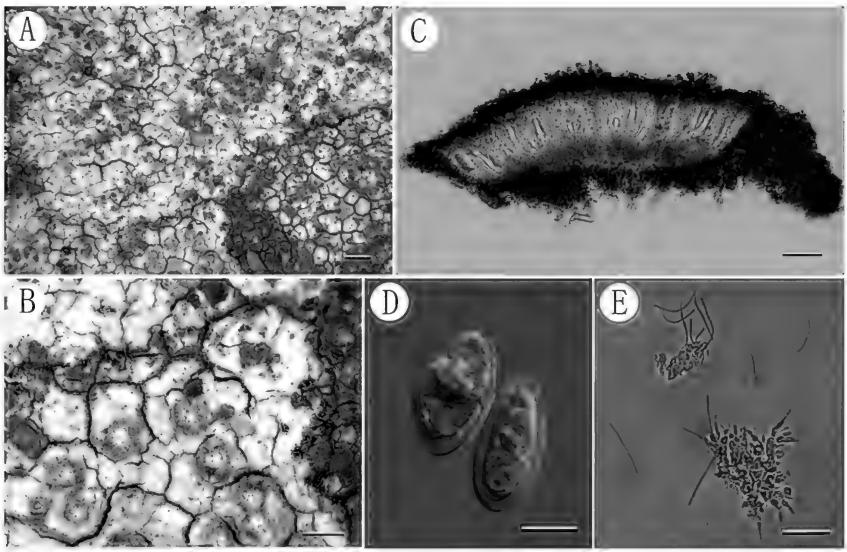

Fig. 4. *Aspicilia nivalis* (holotype, HMAS-L 0139012). A. Thallus on sandstone; B. Thallus with apothecia; C. Apothecial section; D. Ascospores: colorless, simple, ellipsoid; E. Filiform conidia. Scale bars: A = 1 mm; B = 0.5 mm; C = 100 μm; D = 10 μm; E = 20 μm.

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Architrypethelium barrerae sp. nov. from a cloud forest in Veracruz, Mexico

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Abstract—A new species of corticolous microlichen, *Architrypethelium barrerae*, is described from the cloud forest in the ecological park 'El Haya' in Xalapa, Veracruz, Mexico. It is characterized by two-spored asci, cortex UV+ yellow, and an internal K+ pigment in its pseudostromata. Photographs of macro- and microscopic structures are presented.

Key words—tropical lichens, *Trypetheliales*, *Trypetheliaceae*

Introduction

Cloud forests contain the highest vascular plant diversity in Mexico (Rzedowski 1996). Despite the rich documentation of the vascular flora there, lichen diversity from these, as with other tropical regions in Mexico, is poorly known. Although some monographs and synopses have improved our understanding of tropical lichens for some genera (e.g., Ahti 2000, Kurokawa 1962, Lücking 2008), overall little is known about the entire tropical lichen flora. New species have been described from tropical regions (e.g., Córdova-Chávez & al. 2014, Guzmán-Guillermo & al. 2019, Hodkinson & al. 2014) at a rather fast rate considering the paucity of specimens from such regions. This highlights the potential for a great number of overlooked species yet to be described.

Tropical Mexican lichens such as *Trypetheliaceae* are very poorly known, and few reports have been published. This family comprises 16 mostly corticolous genera with perithecioid ascomata, with or without stromatic tissues, and

sometimes with xanthones and anthraquinones (Aptroot & Lücking 2016). Within this family, *Architrypethelium* Aptroot contains perithecioid crustose lichens similar to *Astrothelium* Eschw., but with large (>100 μm), brown, often 3-septate ascospores (Aptroot 1991). To date, this genus includes eight accepted species, of which six are known to occur in the neotropics (Aptroot & al. 2008, Aptroot & Lücking 2016, Flakus & al. 2016, Lücking & al. 2016), one is paleotropical (Luangsuphabool & al. 2018), and one has a pantropical distribution (Aptroot & Lücking 2016).

As part of a larger project, a survey was carried out to collect microlichens in the megadiverse region in the center of Veracruz, a state of Mexico. We collected corticolous microlichens in tropical vegetation, such as the cloud forest in the ecological park 'El Haya' in Xalapa city. One result of our efforts was the discovery of a previously unknown *Architrypethelium*, which we propose as the new species *A. barrerae*.

Materials & methods

The material studied is preserved in the mycology collections in the herbarium of Universidad Veracruzana, Xalapa, Veracruz, Mexico (XALU) and the herbarium of Escuela Nacional de Ciencias Biológicas, Mexico City, Mexico (ENCB). Specimens were collected in El Haya ecological park in Xalapa, Veracruz, México, located at 19.5181°N 96.9436°W and 1300 m a.s.l. Terminology is based on Aptroot & al. (2008) and Aptroot & Lücking (2016), and morphological analysis was conducted by conventional lichenological techniques following Brodo & al. (2001). Sections for anatomical examination were made by hand under a Zeiss Stemi Dv4 stereoscope and microscopical measurements were taken in Lugol's solution using a Zeiss Primo Star microscope. Thin layer chromatography (TLC) was performed using solvent C following conventional chromatography techniques described in Elix (2014). Spot tests used were C (NaClO) and K (KOH 5%). To test hymenium amyloidity, sections of ascomata were mounted with I (Lugol's solution) and resultant coloration was observed.

Taxonomy

Architrypethelium barrerae Guzm.-Guill. & Llar.-Hern., **sp. nov.** FIGS 1, 2

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Differs from *Architrypethelium hyalinum* by its larger ascospores, its two-spored asci, and K+ internal pigment in its pseudostromata.

TYPE: México, Veracruz. Municipio de Xalapa, Parque Ecológico 'El Haya,' 19.5181°N 96.9436°W. 3 October 2020, Guzmán-Guillermo 1968 (**Holotype**, XALU 25326).

ETYMOLOGY: dedicated to Dr. Clementina Barrera-Bernal who supported the lichenological studies by the first author.

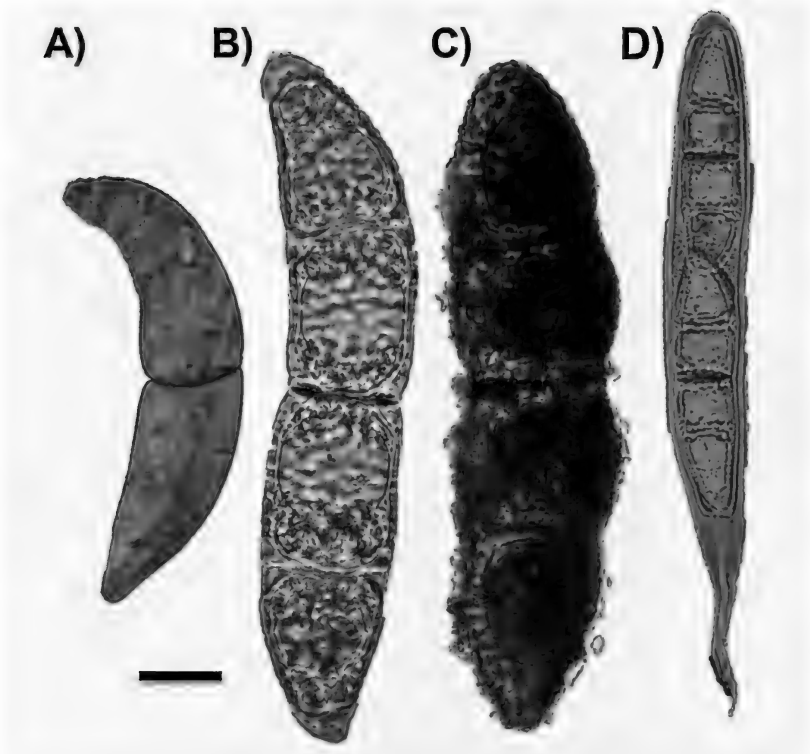

Fig. 1. *Architrypethelium barrerae* (holotype, XALU 25326): A, B. Immature ascospores; C. Mature ascospore; D. Ascus with two spores. Scale bar: A–C = 20 μm; D = 40 μm.

Thallus corticate, green to yellowish, smooth to uneven. Ascomata trypethelioid, with apical ostioles, 0·7–1·2 mm diam., erumpent to prominent, covered by thallus except for the ostiolar area. Ascomata internally with a yellow pigment. Wall fully carbonized and K+ olive green, apical and lateral portions thick, base thin and touching the substrate. Hamathecium not inspersed. Asci cylindrical, longer than 300 μm. Ascospores two per ascus, 160–200 × 50–75 μm, oblong-ellipsoid, triple-septate, outer lumina much smaller than inner lumina, lumina rounded in the corners, brown when free from the ascomata.

Chemistry—Cortex UV+ yellow, thallus K–, yellow pigment K+ yellow to dark red. TLC: lichexanthone and an unidentified anthraquinone.

Ecology & distribution—Corticolous in open areas, in cloud forest at 1300 m a.s.l. Sometimes covered with moss. Known only from the type locality in the El Haya ecological park in Xalapa city, Veracruz, Mexico.

Comments—*Architrypethelium barrerae* is morphologically similar to the other *Architrypethelium* species but contains lichexanthone in its cortex. Within the genus, only *A. hyalinum* Aptroot is known to have this chemistry, but its spores are shorter (160–200 × 30–50 µm) and its asci are 4–8-spored (Aptroot & Lücking 2016). Another characteristic only found in *A. barrerae* is the pseudostromata with a conspicuous internal yellow pigment which is K+ yellow to dark red.

Additional material studied: **MÉXICO, Veracruz. Municipio de Xalapa**, Parque Ecológico 'El Haya', 19.5181°N 96.9436°W, 1300 m a.s.l., 3 October 2020, Guzmán-Guillermo 1969, 1970, 1971, 1972, 1973, 1974, 1975, 1976, 1977 (XALU).

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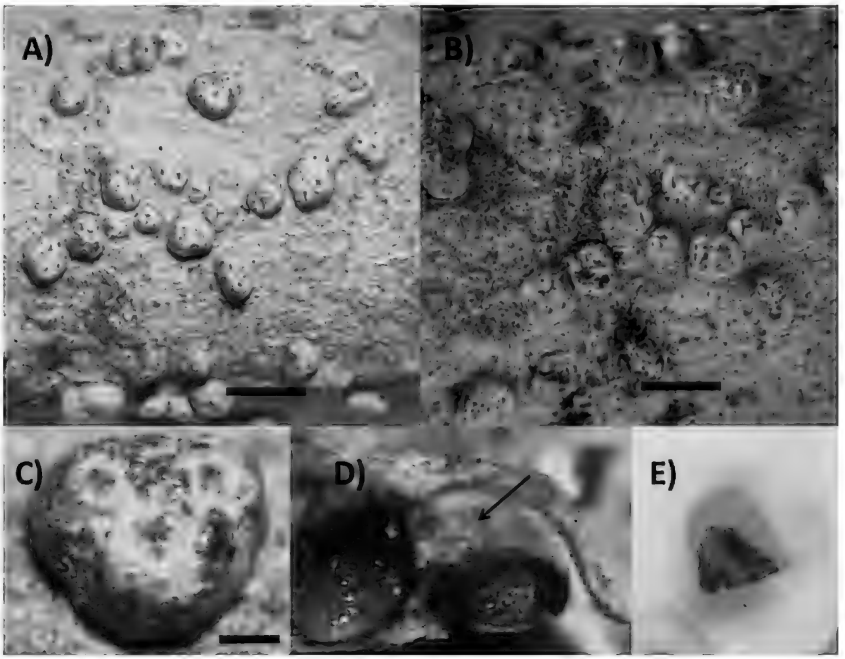

FIG. 2. *Architrypethelium barrerae* (holotype, XALU 25326): A. Thallus; B. Thallus with UV reaction; C. Pseudostroma detail; D. Arrow shows the yellow pigment inside of pseudostroma; E. Yellow pigment reacting to K. Scale bars: A, B = 2 mm; C = 0.4 mm.

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Flavodontia rosea gen. & sp. nov. from southwestern China

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Abstract—A new white-rot corticioid wood-inhabiting fungal genus and species, *Flavodontia rosea*, collected from subtropical Yunnan, China, is proposed based on morphological and molecular evidence. *Flavodontia* is characterized by annual, resupinate basidiomes with a pink hymenial surface, a monomitic hyphal system with generative hyphae bearing simple septa, and ellipsoid basidiospores with thin hyaline smooth walls. Phylogenetic analyses of ITS and ITS + LSU nuclear RNA gene regions showed that *Flavodontia* formed a distinct, monophyletic lineage within a subclade that includes *Flavodon* and *Irpex.*

Key words—*Irpicaceae*, taxonomy, wood-rotting fungi

Introduction

Polyporales, a now well accepted and strongly supported order of *Agaricomycetes,* is one of the most intensively studied groups of fungi of special interest to fungal ecologists and applied scientists (Hibbett & al. 2014; Justo & al. 2017). The most recent Dictionary of the Fungi (Kirk & al. 2008) notes 1589 genera and more than 30,000 species of basidiomycetes (nearly 32% of all described fungal taxa; Dai & al. 2015), of which roughly 1800 described species are included in *Polyporales,* accounting for only about 1.5% of all known fungal species (Kirk & al. 2008). These taxa play a key role as wood-rotting fungi in addition to their pathogenicity and potential applications in biomedical

engineering and biodegradation (Dai & al. 2009, Levin & al. 2016, Bankole & al. 2020).

Polyporales has been sampled extensively in phylogenetic studies using ribosomal RNA (rRNA) genes (Hibbett & Vilgalys 1993, Hibbett & Donoghue 1995, Boidin & al. 1998, Larsson & al. 2004, Binder & al. 2005, Justo & al. 2017, Huang & al. 2020). Justo & al. (2017) included 18 families in their analyses of a 3-gene dataset (292 taxa), providing a phylogenetic overview of *Polyporales* as well as a framework for further taxonomic study. Among these, *Irpicaceae* Spirin & Zmitr. encompassed a great variation of basidiome and hymenophore types, with typical polypore and corticioid morphologies intermixing with each other. A survey of morphological, anatomical, physiological, and genetic traits supported 12 genera in this family.

During investigations of wood-inhabiting fungi in southern China, an unknown taxon was found that could not be assigned to any described genus. Here we expand samplings from other studies to examine the taxonomy and phylogeny of a new genus within the *Irpicaceae* based on the internal transcribed spacer (ITS) regions and the large subunit nrRNA gene (nLSU) sequences.

Materials & methods

The specimens are deposited at the herbarium of Southwest Forestry University, Kunming, P.R. China (SWFC). Macroscopical descriptions are based on field notes of fresh material. Colour terms follow Petersen (1996). Dried specimens were examined microscopically under a light microscope following Dai (2012). The following abbreviations are used: KOH = 5% potassium hydroxide, CB = Cotton Blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = both inamyloid and nondextrinoid, L = mean spore length (arithmetic average for all spores), W = mean spore width (arithmetic average for all spores), Q = variation in the L/W ratios between the specimens studied, n (a/b) = number of spores (a) measured from given number of specimens (b).

A Magen Biotech HiPure Fungal DNA Mini Kit II (Co., Ltd, Guangzhou, Guangdong, P.R. China) was used to extract genomic DNA from dried specimens according to the manufacturer's instructions with some modifications. A small piece (ca. 30 mg) of dried fungal material was ground to powder with liquid nitrogen, transferred to a 1.5 mL centrifuge tube, suspended in 0.4 mL of lysis buffer, and incubated at 65°C in a water bath for 60 min. After 0.4 mL phenol-chloroform (24:1) was added to each tube, the suspension was shaken vigorously. After centrifugation at 13,000 rpm for 30 s, 0.3 mL of supernatant was transferred to a new tube and mixed with 0.45 mL of binding buffer. The mixture was then transferred to an adsorbing column (AC) for centrifugation again for 30 s. Then,

Table 1. Sequences selected for ITS and nLSU phylogenetic analyses

Species name	Specimen no.	GenBank accession no.		References
		ITS	nLSU	
Byssomerulius corium	FP-102382	KP135007	KP135230	Justo & al. 2017
	Wu 1708-327	LC427007	LC427031	Chen & al. 2020a
Ceriporia reticulata	CBS 462.50	MH856710	MH868228	Vu & al. 2019
	RLG-11354-Sp	KP135041	KP135204	Justo & al. 2017
C. viridans	Cui 8012	KC182774	—	Jia & al. 2013
	TNM: GC 1708-211	LC427027	LC427049	Chen & al. 2020a
Emmia lacerata	FP-55521T	KP135024	KP135202	Floudas & Hibbett 2015
E. latemarginata	Dai 7165	KY131834	KY131893	Wu & al. 2017
	CBS 436.48	MH856427	MH867973	Vu & al. 2019
Flavodon flavus	TNM: WHC 1381	LC427029	LC427052	Chen & al. 2020a
	LE295997	KF856505	KF856510	Zmitrovich & Malysheva 2014
Flavodontia rosea	**CLZhao 18491 [T]**	**MW377575**	**MW377578**	**This study**
	CLZhao 18489	**MW377574**	**MW377577**	**This study**
Gloeoporus dichrous	CBS 446.50	MH856705	MH868222	Vu & al. 2019
	Dai 16370A	KU360399	KU360406	Yuan & al. 2016
G. pannocinctus	FCUG 2019	AF141612	AF141612	Yuan & al. 2016
	CBS 291.71	MH860130	MH871903	Vu & al. 2019
G. thelephoroides	BZ-2896	MG572757	MG572741	Jung & al. 2018
Hydnopolyporus fimbriatus	CBS 384.51	MH856910	MH868432	Vu & al. 2019
Irpex lacteus	FD-9	KP135026	KP135224	Justo & al. 2017
	CBS 431.48	MH856423	MH867969	Vu & al. 2019
Leptoporus mollis	RLG7163	KY948794	—	Justo & al. 2017
	TJV-93-174T	KY948795	EU402510	Justo & al. 2017
Meruliopsis leptocystidiata	TNM: Wu 1708-15	LC427012	LC427032	Chen & al. 2020a
	TNM: Wu 1708-43	LC427013	LC427033	Chen & al. 2020a
M. taxicola	CBS 455.48	MH856432	MH867978	Vu & al. 2019
	BU061013-38	MG572756	MG572740	Jung & al. 2018
Phanerochaete rhodella	FD-18	KP135187	KP135258	Justo & al. 2017
P. sordida	FD-241	KP135136	KP135252	Justo & al. 2017
Trametopsis aborigena	Robledo 1236	KY655336	KY655338	Gomez-Montoya & al. 2017
	Robledo 1238	KY655337	KY655339	Gomez-Montoya & al. 2017
T. brasiliensis	Meijer 3637	JN710510	JN710510	Gomez-Montoya & al. 2017
T. cervina	PRM900574	AY684175	AY855907	Tomšovský & al. 2006

0.5 mL of inhibitor removal fluid was added in AC for a centrifugation at 12,000 rpm for 30 s. After washing twice with 0.5 mL of washing buffer, the AC was transferred to a clean centrifuge tube, and 100 mL elution buffer was added to the middle of adsorbed film to elute the genomic DNA. The ITS region was amplified with primers ITS5 and ITS4 (White & al. 1990), and the nLSU region was amplified with primers LR0R and LR7 (http://www.biology.duke.edu/fungi/mycolab/primers.htm). The ITS PCR protocols involved initial denaturation at 95°C for 3 min, 35 cycles at 94°C for 40 s + 58°C for 45 s + 72°C for 1 min, and a final 10-min extension at 72°C. The nLSU PCR protocols involved initial denaturation at 94°C for 1 min, followed by 35 cycles at 94°C for 30 s + 48°C for 1 min + 72°C for 1.5 min, and a final 10-min extension at 72°C. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited in GenBank (Table 1).

Sequences were aligned in MAFFT 7 (http://mafft.cbrc.jp/alignment/server/) using the "G-INS-I" strategy for nLSU and "E-INS-I" strategy for ITS + nLSU and manually adjusted in BioEdit (Hall 1999). Alignment datasets were deposited in TreeBase (submission ID 27155). *Phanerochaete sordida* and *P. rhodella* sequences obtained from GenBank were used as outgroup to root trees following Justo & al. (2017) in the ITS (Fig. 1) and ITS + nLSU (Fig. 2) phylogenetic trees.

Maximum parsimony analyses were applied to the ITS and ITS + nLSU dataset sequences following Zhao & Wu (2017), and the tree was generated in PAUP* v. 4.0b10 (Swofford 2002). All characters were equally weighted with gaps treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed and all parsimonious trees were saved. Clade robustness was assessed using a bootstrap (BT) analysis with 1000 replicates (Felsenstein 1985). Tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each Maximum Parsimonious Tree. The data matrix was also analyzed using Maximum Likelihood (ML) approach with RAxML-HPC2 through the Cipres Science Gateway (www.phylo.org; Miller & al. 2009). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicates.

MrModeltest 2.3 (Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian inference (BI). BI was calculated with MrBayes 3.1.2 with a general time reversible (GTR) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 70,000 generations for ITS (Fig. 1), 200,000 generations for ITS + nLSU (Fig. 2) and trees were sampled every 100 generations. The first one-fourth generations were discarded as burn-in. A majority rule consensus tree of all remaining trees was calculated. Branches were considered as significantly supported if they received maximum likelihood bootstrap (BS) >70%, maximum parsimony bootstrap (BT) >50%, or Bayesian posterior probability (BPP) >0.95.

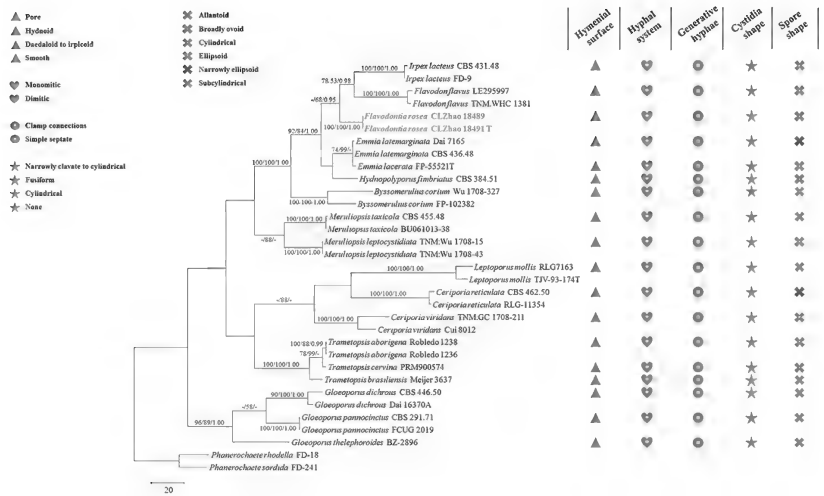

FIG. 1. Maximum Parsimony strict consensus tree illustrating the phylogeny of *Flavodontia rosea* and related species in *Irpicaceae* based on ITS sequences. Branches are labelled with maximum likelihood bootstrap >75%, parsimony bootstrap >50%, and Bayesian posterior probability >0.95.

Phylogenetic results

The ITS dataset included sequences from 33 fungal specimens representing 20 taxa and with an aligned length of 666 characters, of which 358 characters were constant, 36 variable and parsimony-uninformative, and 272 parsimony-informative. Maximum parsimony analysis yielded 3 equally parsimonious trees (TL = 927, CI = 0.537, HI = 0.463, RI = 0.731, RC = 0.393). Best model for ITS estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian analysis produced a similar topology with an average standard deviation of split frequencies = 0.009412.

The phylogenetic tree (FIG. 1) inferred from ITS sequences obtained from related genera in *Irpicaceae* demonstrated that the new genus formed a monomitic lineage and then grouped with a clade including *Flavodon* Ryvarden and *Irpex* Fr.

The ITS + nLSU dataset (FIG. 2) included sequences from 33 fungal specimens, also representing 20 species. The dataset had an aligned length of 1702 characters, of which 1120 characters were constant, 146 variable and parsimony-uninformative, and 436 parsimony-informative. Maximum

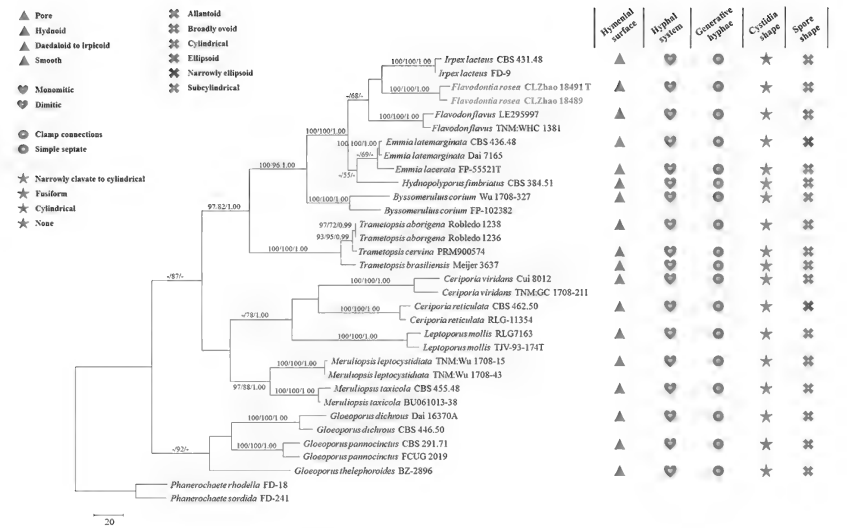

FIG. 2. Maximum Parsimony strict consensus tree illustrating the phylogeny of *Flavodontia rosea* and related species in *Irpicaceae* based on ITS + nLSU sequences. Branches are labeled with maximum likelihood bootstrap >75%, parsimony bootstrap >50%, and Bayesian posterior probability >0.95.

parsimony analysis yielded 2 equally parsimonious trees (TL = 1382, CI = 0.587, HI = 0.413, RI = 0.754, RC = 0.442). Best model for the nLSU dataset estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian and ML analyses produced a similar topology as MP analysis, with an average standard deviation of split frequencies = 0.009828.

The additional phylogeny (FIG. 2) inferred from ITS + nLSU sequences grouped the new species with the related species *Flavodon flavus* (Klotzsch) Ryvarden and *Irpex lacteus* (Fr.) Fr.

Taxonomy

Flavodontia C.L. Zhao, **gen. nov.**

MB 838322

Differs from *Flavodon* by its resupinate basidiomata, smooth hymenial surface, monomitic hyphal system, and ellipsoid basidiospores.

TYPE SPECIES: *Flavodontia rosea* C.L. Zhao

ETYMOLOGY: *Flavodontia* (Lat.): referring to the closely related genus, *Flavodon*.

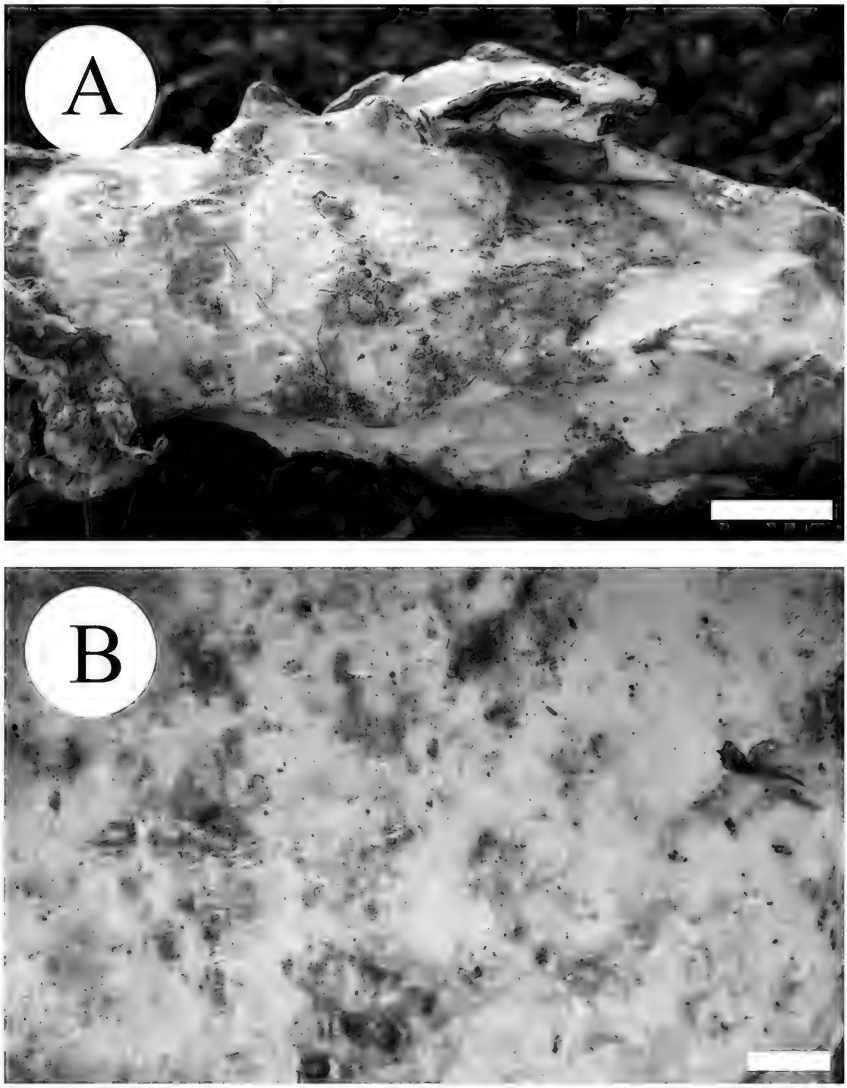

FIG. 3. *Flavodontia rosea* (holotype, SWFC 018491).
Basidiomata. Scale bars: A = 0.5 cm; B = 1 mm.

BASIDIOMATA annual, resupinate, smooth hymenial surface, fragile to rigid upon drying. Hyphal system monomitic; generative hyphae bearing simple septa, IKI–, CB–; tissues unchanged in KOH. Cystidia and cystidioles absent.

Basidia clavate. Basidiospores ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–.

Type of rot: white.

Flavodontia rosea C.L. Zhao, **sp. nov.** Figs 3, 4

MB 838323

Differs from *Flavodon flavus* by its resupinate basidiomata with buff to slightly rose to rose hymenial surface, its monomitic hyphal structure, and its smaller basidiospores.

Type: China. Yunnan Province: Honghe, Pingbian County, Daweishan National Nature Reserve, 22.93°N 103.68°E, alt. 1714 m, on an angiosperm trunk, 3 August 2019, CLZhao 18491 (**Holotype**, SWFC 018491; GenBank MW377575, MW377578).

Etymology: From *rosea* (Lat.), referring to the rose hymenial surface of the basidiome.

Basidiomata annual, resupinate, coriaceous, without odour or taste when fresh, becoming fragile to rigid upon drying, ≤8 cm long, 3 cm wide, 500–800 μm thick. Hymenial surface smooth, buff to slightly rose to rose when fresh, becoming rose-coloured upon drying. Subiculum very thin, 0.2 mm thick, buff to slightly rose. Margin sterile, cream to buff, 2 mm wide.

Hyphal structure monomitic; generative hyphae with simple septa, colourless, thin to thick-walled, rarely branched, 3–4.5 μm diam., IKI–, CB–; tissues unchanged in KOH.

Hymenium cystidia and cystidioles absent; basidia clavate, 19–26.5 × 3–4 μm, with four sterigmata and a basal simple septum; basidioles dominant, in shape similar to basidia, but slightly smaller.

Basidiospores ellipsoid, colourless, thin-walled, smooth, IKI–, CB–, (3.1–)3.3–4.6(–4.8) × (2.5–)2.7–3.5 μm, L = 3.99 μm, W = 3.06 μm, Q = 1.29–1.30 (n = 60/2).

Type of rot: white rot.

Additional specimen examined: **China. Yunnan province. Honghe:** Pingbian County, Daweishan National Nature Reserve, on the angiosperm trunk, 3 August 2019, CLZhao 18489 (SWFC 018489; GenBank MW377574, MW377577).

Comments: *Flavodon flavus* differs from *Flavodontia rosea* by pileate basidiomata with a poroid hymenophore surface that becomes hydnoid to irpicoid with time, a dimitic hyphal structure with thick-walled skeletal hyphae, and larger basidiospores (5.5–6.5 × 3–4 μm; Ryvarden 1973).

Discussion

Phylogenetic and morphological analyses strongly support *Flavodontia* as an independent genus that clusters with related taxa in *Irpicaceae*. Phylogenetically, *Flavodontia* is closely related to *Flavodon* and *Irpex* based

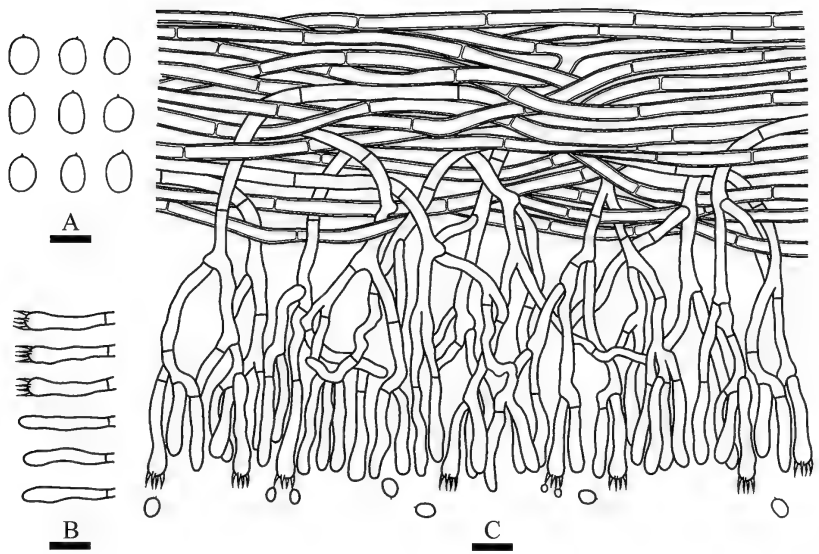

Fig. 4. *Flavodontia rosea* (drawn from the holotype, SWFC 018491).
A. Basidiospores; B. Basidia and basidioles; C. Section of hymenium.
Scale bars: A = 5 μm; B, C = 10 μm.

on ITS and ITS + LSU nRNA gene analyses (Figs 1 & 2) in agreement with multigene analyses by Justo & al. (2017). *Flavodon* is morphologically distinguished by pileate basidiomata with poroid to irpicoid hymenophores and encrusted cystidia (Ryvarden 1973), and *Irpex* differs from *Flavodontia* by its poroid to hydnoid hymenophore with irregular/irpicoid pores and dimitic hyphal system (Fries 1825, Bernicchia & Gorjón 2010).

The consensus phylogram of the comprehensive taxon dataset from 12 agaricomycete orders from ITS, LSU, mtSSU, atp6, tef1, and rpb2 grouped *Flavodon*, *Irpex*, and *Trametopsis* Tomšovský together in a clade labelled "*Byssomerulius* family" (Miettinen & al. 2012). A subsequent phylogenetic tree based on a 3-gene dataset and including more sequences and taxa in *Irpicaceae* supported *Emmia* Zmitr. & al. as sister to *Irpex* and clustered with *Trametopsis* (Justo & al. 2017). The relationships among different taxa in *Irpicaceae* from both studies (Miettinen & al. 2012, Justo & al. 2017) differed due to 3-gene and 6-gene datasets.

In the present study, the ITS (Fig. 1) and ITS + nLSU (Fig. 2) phylograms are very similar, clustering four genera together in agreement with previous studies and supporting *Flavodontia* as an independent genus. The different

symbols and colors in Figs 1 & 2 show that the macromorphological hymenophore characters are not consistent and regular across *Flavodontia* and related genera. However, the micromorphological data (hymenial surface, hyphal system, generative hyphae, and cystidial and spore shapes) show that four closely related genera *Emmia*, *Flavodon*, *Flavodontia*, and *Irpex* share the same character of simple septate generative hyphae, suggesting that micromorphology is less affected by the environment than macromorphology and thus more indicative of phylogenetic relationships.

Irpicioid fungi represent an extensively studied group of *Polyporales* (Núñez & Ryvarden 2001, Bernicchia & Gorjón 2010, Dai 2012, Ryvarden & Melo 2014, Dai & al. 2015), but the Chinese irpicioid fungus diversity is still not well known, especially in subtropics and tropics where many new taxa, including *Flavodontia,* have recently been described (Zhao & al. 2017, Shen & al. 2018, Cui & al. 2019, Ma & Zhao 2019, Chen & al. 2020b, Huang & al. 2020). We anticipate that more undescribed irpicioid taxa will be discovered throughout China after extensive collection combined with morphological and molecular analyses.

Acknowledgements

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Pseudodeightoniella indica gen. and sp. nov., a hyphomycete from India

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Abstract—An interesting new mitosporic foliicolous genus and species, *Pseudodeightoniella indica*, discovered on living leaves of *Medicago polymorpha* (*Fabaceae*) from Uttarakhand, India, is described and illustrated. Morphologically, *Pseudodeightoniella* differs from the closely similar *Deightoniella* and *Neodeightoniella* in producing well-developed erumpent stromata, highly undulate to spiral or helicoid and densely fasciculate conidiophores with enlarged basal cells, and conidia lacking mucoid caps. Recently published illustrations of conidia and conidiophores characterizing the *Deightoniella* and *Neodeightoniella* type species are also provided.

Key words—asexual fungi, biodiversity, plant disease, taxonomy

Introduction

Deightoniella S. Hughes was introduced with type species *D. africana* S. Hughes (Hughes 1952). The main diagnostic features of *Deightoniella* are mononematous brown conidiophores that are torsive or flexuous and typically nodulated or annellated by the outer wall after each enteroblastic precurrent proliferation of the conidiogenous cells and obclavate to obpyriform, subhyaline to olivaceous brown, minute verruculose, transversely 1–2-septate

conidia with the septum above the median and the apical cell prominently tapering towards subobtuse apex (Hughes 1952, Klaubauf & al. 2014, Videira & al. 2017). Multigenic analysis by Klaubauf & al. (2014) placed *Deightoniella* in a new family, *Pyriculariaceae.*

Similar to *Deightoniella* is *Neodeightoniella* Crous & W.J. Swart, described in 2013 with the type species *N. phragmiticola* Crous & W.J. Swart (Crous & al. 2013). *Neodeightoniella* differs from *Deightoniella* in producing less fasciculate, straight (to slightly flexuous) sub-cylindrical conidiophores produced from a poorly developed stromata of a few brown cells; terminal and integrated conidiogenous cells; dark thickened scars; and 1-septate fusoid-ellipsoid conidia with apical cells that are globose and with prominent mucoid cap and funnel-shaped basal cells that are widest two thirds from the basal hilum before tapering prominently to a truncate, darker and thickened hilum, hilum with a central pore (Crous & al. 2013, Videira & al. 2017). Phylogenetically, *Neodeightoniella* clusters in the *Mycosphaerellaceae* (Videira & al. 2017). Fifteen *Deightoniella* and one *Neodeightoniella* species are currently accepted (www.indexfungorum.org; accessed 15 August 2020).

During the past decade, several asexual foliicolous fungi have been described from north India (Awasthi & al. 2016; Kumar & Singh 2015a,b, 2016; Kumar & al. 2012a,b, 2018; Kushwaha & al. 2020; Singh & Kamal 2011; Singh & al. 2011, 2012, 2013a,b, 2014a,b, 2019), suggesting that such fungi are highly diverse and in need of additional exploration and characterization. During a systematic survey of conidial fungi in the forests of Nainital, Uttarakhand, an interesting species was collected on young living leaves of *Medicago polymorpha*. Morphologically, this unknown fungus somewhat resembled *Deightoniella* and *Neodeightoniella* but was sufficiently distinct to warrant our proposal of it as a new genus and species.

Materials & methods

In October 2018, infected leaves of *Medicago polymorpha* were collected near Bhimtal of Nainital, Uttarakhand, during field survey, and the collected samples were kept in sterilized polythene bag for transport to the laboratory where they were processed according to standard techniques (Hawksworth 1974, Savile 1962). Slides for microscopic examination were prepared by scraping specimens from infected areas, hand sectioning, and mounted in clear lacto-phenol cotton blue mixture and clear glycerin. The microphotographs of fungal propagules were taken using Magnus MIPS CMOS camera attached to an Olympus CH20i-TR compound microscope. The detailed morphological observations and Lucida drawings were conducted at different magnifications (100×, 450×, 1000×), and 20 measurements were made of each morphological feature. The holotype specimen was deposited in the Ajrekar

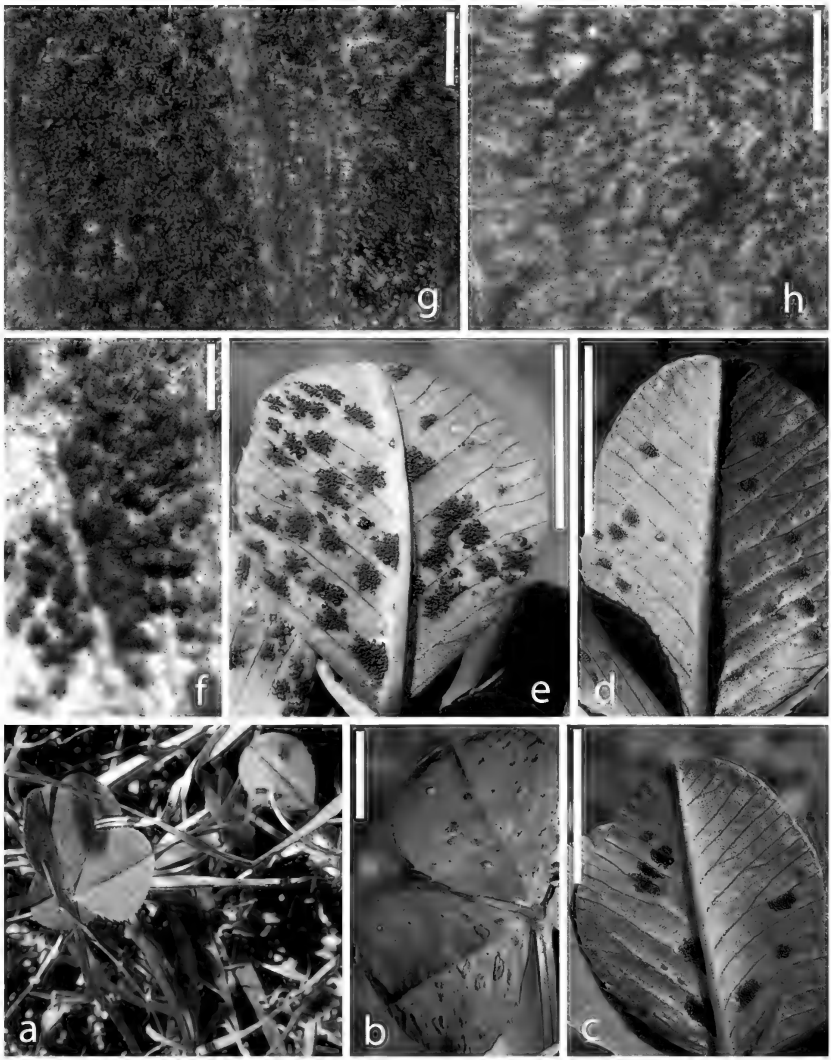

Fig. 1. *Pseudodeightoniella indica* on *Medicago polymorpha*. a. Host plant in natural habitat; b. Symptom on upper surface of leaflets; c, d. Initial stages on infection on lower surfaces of leaflets; e. Late stage of infection on lower surface of leaflet; f–h. Colonies of fungal pathogen at high magnifications. Scales bars: b–e = 5 mm; f, g = 200 µm; h = 100 µm.

Mycological Herbarium, Agharkar Research Institute, Pune, India (AMH), and an isotype is retained in the Mycological Herbarium of the Department of Botany, Banaras Hindi University, Varanasi, India (MH-BHU).

Taxonomy

Pseudodeightoniella S.K. Verma, Sanj. Yadav & Raghv. Singh, **gen. nov.**

MB 836237

Differs from *Deightoniella* and *Neodeightoniella* by its very well-developed erumpent stromata, densely fasciculate and undulate to spiral or helicoid conidiophores with swollen basal cell, and conidia without mucoid cap.

Type Species: *Pseudodeightoniella indica* S.K. Verma & al.

Etymology: In reference to partial morphological similarity to the genus *Deightoniella*.

Colonies hypophyllous, scattered, dark brown to blackish brown. Mycelium internal. Stromata well-developed, prosenchymatous to pseudoparenchymatous, erumpent, mid- to dark brown. Conidiophores macronematous, densely fasciculate, arising from stromata, sub-cylindrical, straight to slightly flexuous, undulate to spiral/helicoid, unbranched, smooth to finely roughened, mid- to dark brown, septate, bearing swollen tubular or oval shaped basal cells that aggregate at the top of stromata. Conidiogenous cells integrated and terminal, sub-cylindrical, mid brown to dark brown, slightly lighter towards apex, finely roughened, enteroblastic, mono to polytretic; scars terminal and lateral on conidiogenous cells, thickened and darkened, slightly protruding, circular with central pore. Conidial secession schizolytic. Conidia solitary, mid- to dark brown, surface smooth to finely roughened, mostly obpyriform to cuneiform, slightly curved, apical cell globose, basal cell more or less funnel shaped, aseptate to septate with septum medially placed, tapering towards truncate hilum, hilum slightly thickened and dark.

Pseudodeightoniella indica S.K. Verma, Sanj. Yadav & Raghv. Singh, **sp. nov.** Figs 1–4

MB 836238

Differs from *Deightoniella africana* by its septate conidiophores with larger basal cell and smaller conidia without any kind of conical shaped apical cell and from *Neodeightoniella phragmiticola* by its shorter, thinner conidiophores and smaller conidia lacking any mucoid cap on apical cells.

Type: India, Uttarakhand, Nainital, Bhimtal, 29.3919°N 79.4542°E, on living leaves of *Medicago polymorpha* L. (*Fabaceae*), 20th October 2018, coll. Sanjeet Kumar Verma (**Holotype**, AMH 10239; **isotype**, MH-BHU 19).

Etymology: Derived from the name of country where the taxon was discovered.

Infection spots hypogenous, brown to dark blackish brown, velvety, scattered, initially circular to subcircular but later becoming irregular, 0.2–1.1 mm in diam. Colonies hypophyllous, scattered, dark brown to

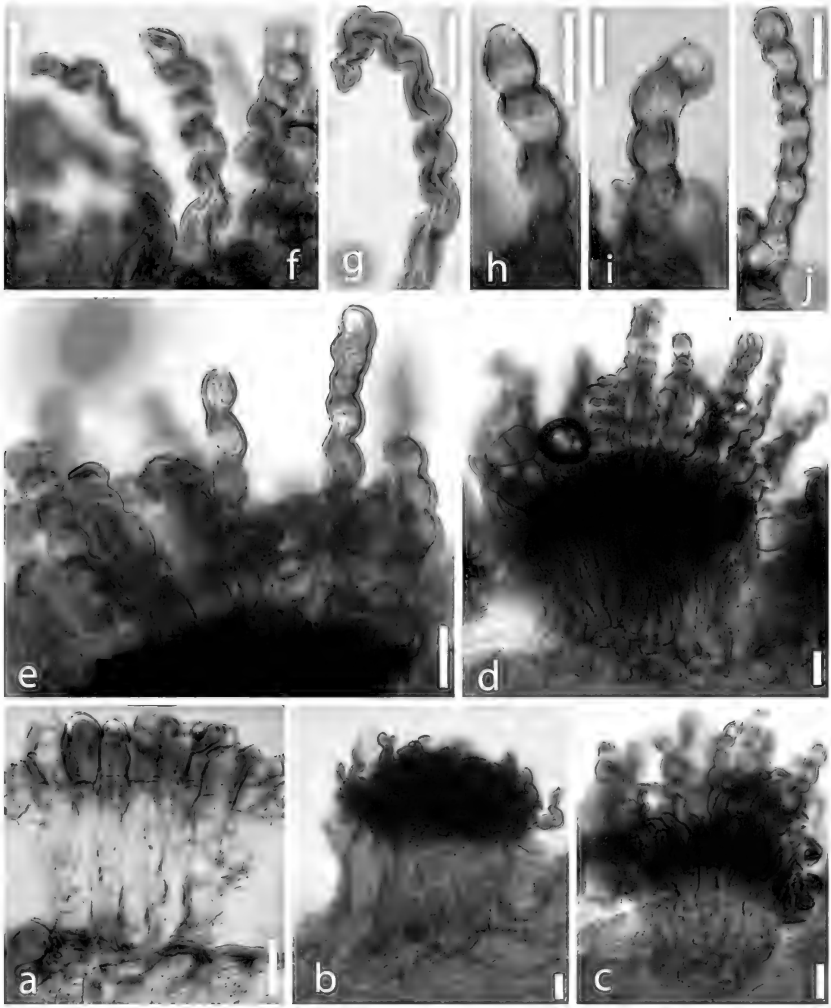

Fig. 2. *Pseudodeightoniella indica* (holotype, AMH 10239). a. Initial stage of development of stromata lined by basal swollen cells of conidiophores; b. Initial stage of development of conidiophores from swollen basal cells; c, d. Fully developed stage of undulating conidiophores in fascicle; e. Undulating nature of conidiophores; f–j. Different forms of conidiophores. Scale bars: 10 μm.

blackish brown. Mycelium immersed, medium brown. Stromata well-developed, prosenchymatous to pseudoparenchymatous, erumpent, mid brown to dark brown, 30–70 × 50–90 μm. Conidiophores macronematous,

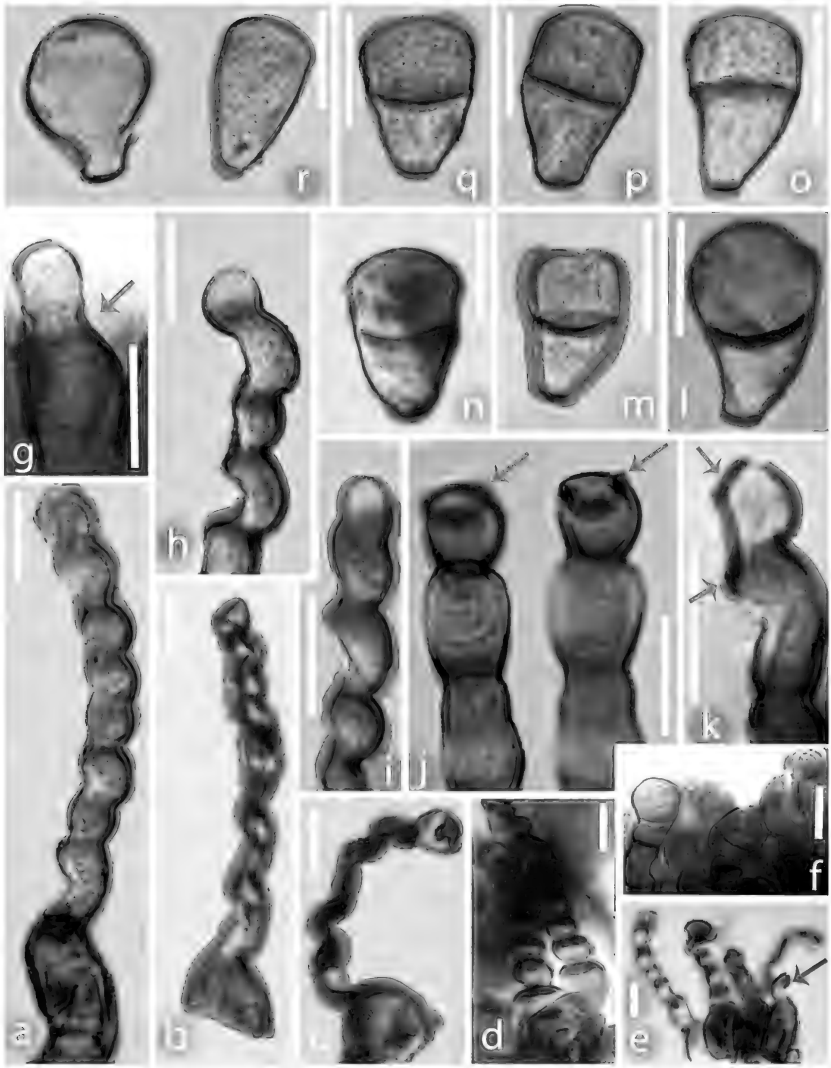

Fig. 3. *Pseudodeightoniella indica* (holotype, AMH 10239). a–e. Undulating conidiophores bearing basal swollen cells (green arrow for initial stage of development of conidiophores from basal cell); f. Conidiophores with developing conidia; g–i. Enteroblastic nature of conidial ontogeny (blue arrow); j, k. Conidiogenous cells with circular loci having central pore (red arrows); l–r. Conidia. Scale bars: 10 µm.

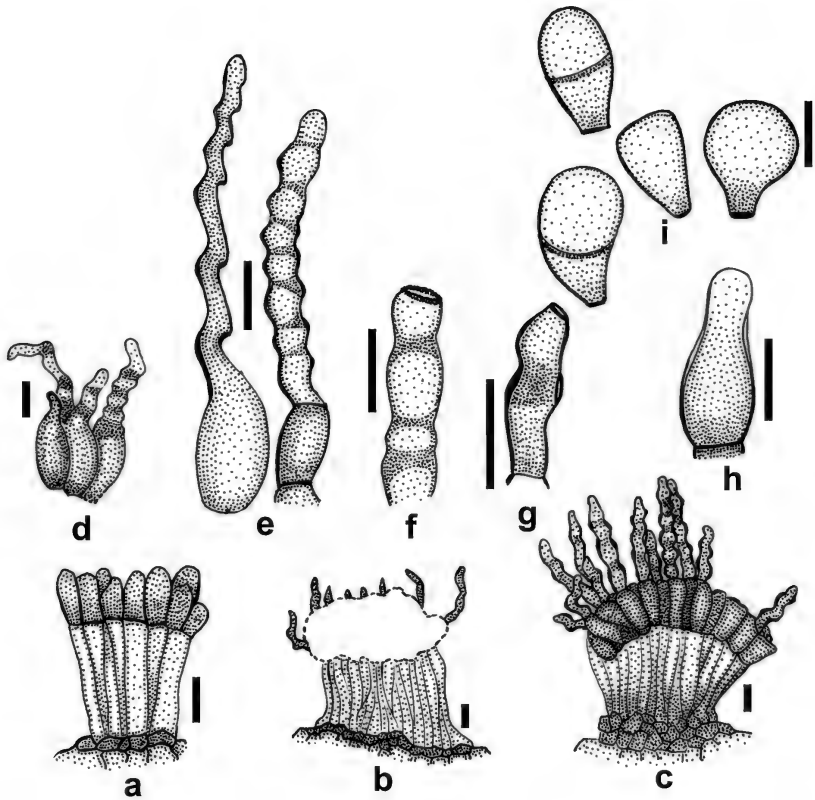

FIG. 4. *Pseudodeightoniella indica* (holotype, AMH 10239). a. Initial stage of development of stromata lined by basal swollen cells of conidiophores; b. Initial stage of development of conidiophores from swollen basal cells; c. Developed stage of undulating conidiophores in fascicle; d. Initial developmental stage of conidiophores with basal cells; e. Different forms of developed conidiophores with basal cells; f, g. Conidiogenous cells with loci; h. Enteroblastic development of conidium; i. Conidia. Scale bars: 10 μm.

densely fasciculate, arising from stromata, sub-cylindrical, straight to slightly flexuous, undulate to spiral/helicoid, unbranched, smooth to finely roughened, medium to dark brown, 0–2-septate, 20–50 × 2–6.5 μm (excluding basal cells), bearing swollen tubular or oval basal cells (15–26 × 7–14 μm) that form aggregations (70–85 × 25–40 μm) at the tops of stromata. CONIDIOGENOUS CELLS integrated and terminal, sub-cylindrical, mid brown to dark brown, slightly lighter towards apex, finely roughened, enteroblastic, mono to polytretic, 6–16 × 3–6.5 μm; scars terminal and lateral

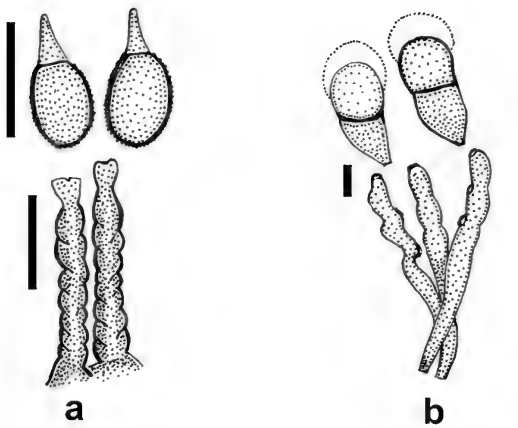

Fig. 5. ***Deightoniella africana***: a. Conidia and conidiophores (Videira & al. 2017). ***Neodeightoniella phragmiticola***: b. Conidia and conidiophores (Crous & al. 2013). Scale bars: 10 μm.

on conidiogenous cells, thickened and dark, slightly protruding, circular with central pore, 2.2–4.3 μm diam. Conidial secession schizolytic. Conidia solitary, medium to dark brown, surface smooth to finely roughened, mostly obpyriform to cuneiform, slightly curved, 13.5–18.5 × 8.5–11.5 μm, apical cell globose, basal cell more or less funnel-shaped, aseptate to 1-septate, septum medially placed, tapering towards truncate hilum, hilum slightly thickened and darkened, 2.6–4.1 μm wide.

Comments—*Pseudodeightoniella* shares a superficial morphological similarity with *Deightoniella* (Hughes 1952, Klaubauf & al. 2014, Videira & al. 2017) and *Neodeightoniella* (Crous & al. 2013, Videira & al. 2017) due to the undulate nature of the conidiophores. *Deightoniella*, however, is distinguished by its lack of stromata; solitary, torsive or flexuous conidiophores; monotretic conidiogenous cells, and conidia that are transversely 1-septate above the median and with the apical cell prominently tapering towards the sub-obtuse apex; the conidiophore of *Deightoniella* shows characteristic swellings along the conidiophore length resulting from percurrent rejuvenation and conidiophore elongation (e.g., *D. africana,* Fig. 5a). *Pseudodeightoniella* is distinct from *Neodeightoniella*, which has

very poorly developed stromata (composed of only a few cells), conidia with globose apical cells bearing a prominent mucoid cap, and an absence of percurrent rejuvenation and any swollen tubular or oval shaped basal cells in the conidiophores (e.g., *N. phragmiticola,* Fig. 5b).

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Lepra yunlingensis and *L. taiwanensis* spp. nov. from China

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Abstract—Two new species of *Lepra* are described from China: *L. yunlingensis* is characterized by its 2-spored asci and the presence of norstictic and cryptostictic acids; *L. taiwanensis* is characterized by its 1-spored asci and the presence of barbatic acid.

Key words—lichenized fungi, *Pertusaria*, *Pertusariaceae*, *Pertusariales*, taxonomy

Introduction

Based on a combination of morphological and chemical characters, *Pertusaria* DC. was divided into three subgenera (Archer 1993). The earlier name *Lepra* Scop., rejected against the conserved *Pertusaria*, which could accommodate the species of *P.* subgen. *Monomurata* A.W. Archer (Archer 1993) or the "*Variolaria*"-group (Schmitt & Lumbsch 2004) of *Pertusaria* s.lat., was resurrected by Hafellner & Türk (2016). That circumscription of the genus *Lepra* is now accepted by other lichenologists (Lendemer & Harris 2017, Archer & Elix 2018, Ren 2019).

Lepra is characterized by its crustose thallus, disciform apothecia, 1–2 (–rarely 8)-spored asci, large hyaline ascospores, and the presence of a diversity of lichen substances, such as depsone, depsidones, β-orcinol m-depsides, β-orcinol p-depsides, fatty acids, and lichexanthone (Archer & Elix 2018).

In the course of reexamining *Lepra* specimens in KUN, two new species of *Lepra* were encountered that are described here.

Materials & methods

The specimens examined in this study were deposited in the Herbarium at Kunming Institute of Botany, Chinese Academy of Sciences, Yunnan, China (KUN).

Macromorphological characters were observed using a stereo microscope and micromorphological characters were examined by hand-cut sections under a light microscope. The lichen products were detected primarily by spot tests K = a aqueous solution of 10% potassium hydroxide (KOH), C = a saturated aqueous solution of calcium hypochlorite ($Ca(ClO)_2$), KC = K solution followed by C] and thin-layer chromatography (TLC) with solvent systems A, B, and C (Elix 2014).

Taxonomy

Lepra yunlingensis Q. Ren, **sp. nov.** FIG. 1

FN 570769

Differs from *Lepra wulingensis* by its 2-spored asci and the absence of psoromic acid.

TYPE: China. Yunnan, Nanjian County, Lingbaoshan National Park, 24.7700°N 100.4961°E, alt. 2355 m, on bark, 29 Jun. 2015, X. Ye 15-47837 & W.C. Wang (**Holotype**, KUN).

ETYMOLOGY: The epithet refers to the name of the type locality, the Yunling Mountains.

THALLUS corticolous, crustose, verrucose to verruculose, thin, grayish green; margin indistinct; prothallus not visible; isidia absent; soredia present, granular, restricted to the verrucae. VERRUCAE sorediate, numerous, crowded but rarely fused, c. 1.0 mm in diam. APOTHECIA 1 (less often 2–3) per verruca, with pinkish discs densely covered with white pruina. ASCOSPORES 2 per ascus, uniseriate longitudinally, hyaline, 57–97 × 33–48 µm; ascospore wall smooth. PYCNIDIA not observed.

CHEMISTRY: Medulla K+ yellow turning red, C–, KC–. Containing norstictic acid and cryptostictic acid.

REMARKS: Diagnostic characters for *L. yunlingensis* are a thin corticolous thallus, granular soredia restricted to verrucae, pinkish discs covered with white pruina, 2-spored asci, and the presence of norstictic and cryptostictic acids. Morphologically, the new species is very similar to *L. wulingensis* (Z.T. Zhao & Z.S. Sun) Q. Ren, which differs in its 8-spored asci and presence of psoromic acid (Ren & al. 2009, as *Pertusaria wulingensis*).

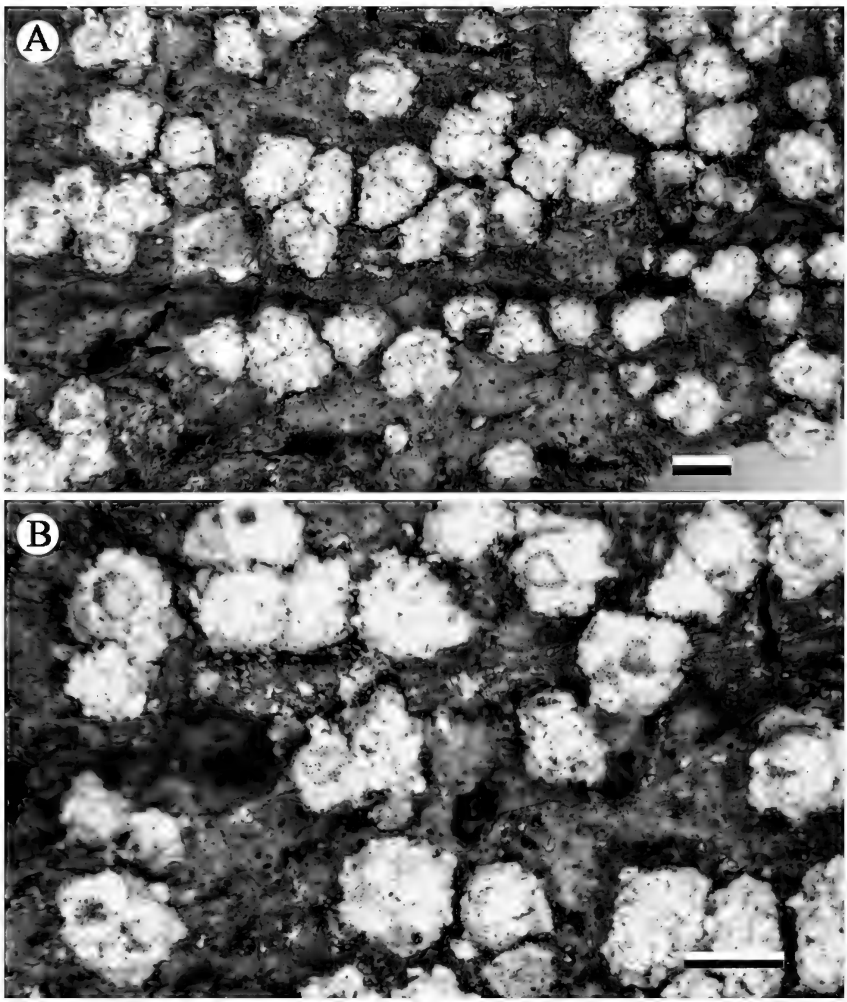

Fig. 1. *Lepra yunlingensis* (KUN – Ye 15-47837). A. Thallus with numerous verrucae. B. Detail of verrucae, showing disks covered with white pruina. Scale bars = 1 mm.

Lepra bambusetorum (Zahlbr.) Q. Ren, *L. composita* (Zahlbr.) Q. Ren, and *L. trachythallina* (Erichsen) Lendemer & R.C. Harris are three species known from China that produce disciform apothecia and 2-spored asci. However, they are separated from *L. yunlingensis* by the presence of different lichen substances:

salazinic acid in *L. bambusetorum*, protocetraric acid in *L. composita*, and thamnolic acid in *L. trachythallina* (Ren 2019).

Lepra taiwanensis Q. Ren, **sp. nov.** FIG. 2

FN 570770

Differs from *Lepra multipunctoides* by its pinkish discs and the absence of fumarprotocetraric acid.

TYPE: China. Taiwan, Nantou County, Mt. Hehuan, 24.1358°N 121.2872°E, alt. 3303 m, on bark of *Abies* sp., 23 Sep. 2015, L.S. Wang 15-49266 & X.Y. Wang (**Holotype**, KUN).

ETYMOLOGY: The epithet refers to the name of the type locality, Taiwan.

THALLUS corticolous, crustose, thin, whitish to grayish; prothallus distinct, whitish; isidia absent; soredia fine and restricted to the verrucae, white. VERRUCAE abundant, rounded in outline, 1–1.5 mm in diam., punctiform to hemispherical when young, pseudocyphella-like. APOTHECIA 1–4 per verruca, with pinkish discs densely covered with white pruina. ASCOSPORES 1 per ascus, usually immature, hyaline, ellipsoid, 70–205 × 20–81 µm; ascospore wall smooth, c. 13 µm thick. PYCNIDIA not observed.

CHEMISTRY: Medulla K–, C–, KC+ pink. Containing barbatic acid.

ADDITIONAL SPECIMEN EXAMINED—**CHINA. TAIWAN, Nantou County**, Mt. Hehuan, 24.1358°N 121.2872°E, alt. 3303 m, on *Abies* bark, 23 Sep. 2015, L.S. Wang 15-49219 & X.Y. Wang (KUN).

REMARKS: Diagnostic characters for *L. taiwanensis* are a thin whitish to grayish corticolous thallus, fine soredia restricted to verrucae, pinkish discs densely covered with white pruina, 1-spored asci, and the presence of barbatic acid. Morphologically, the new species resembles *L. multipunctoides* (Dibben) Lendemer & R.C. Harris and the abundantly collected species identified by Chinese lichenologists as *L. amara* (Ach.) Hafellner, but *L. multipunctoides* contains fumarprotocetraric acid and *L. amara* contains picrolichenic acid (Ren 2019).

Barbatic acid is also known from two other *Lepra* species: *L. barbatica* (A.W. Archer & Elix) I. Schmitt & al. and *L. wirthii* (Elix & A.W. Archer) I. Schmitt & al. *Lepra barbatica* is a sterile, isidiate species occurring in Eastern Australia and New Zealand (Archer 1997, Galloway 2007; as *Pertusaria barbatica*); *L. wirthii* has black discs and larger ascospores (200–240 × 56–70 µm) and occurs in New Zealand (Archer & Elix 2013, as *Pertusaria wirthii*).

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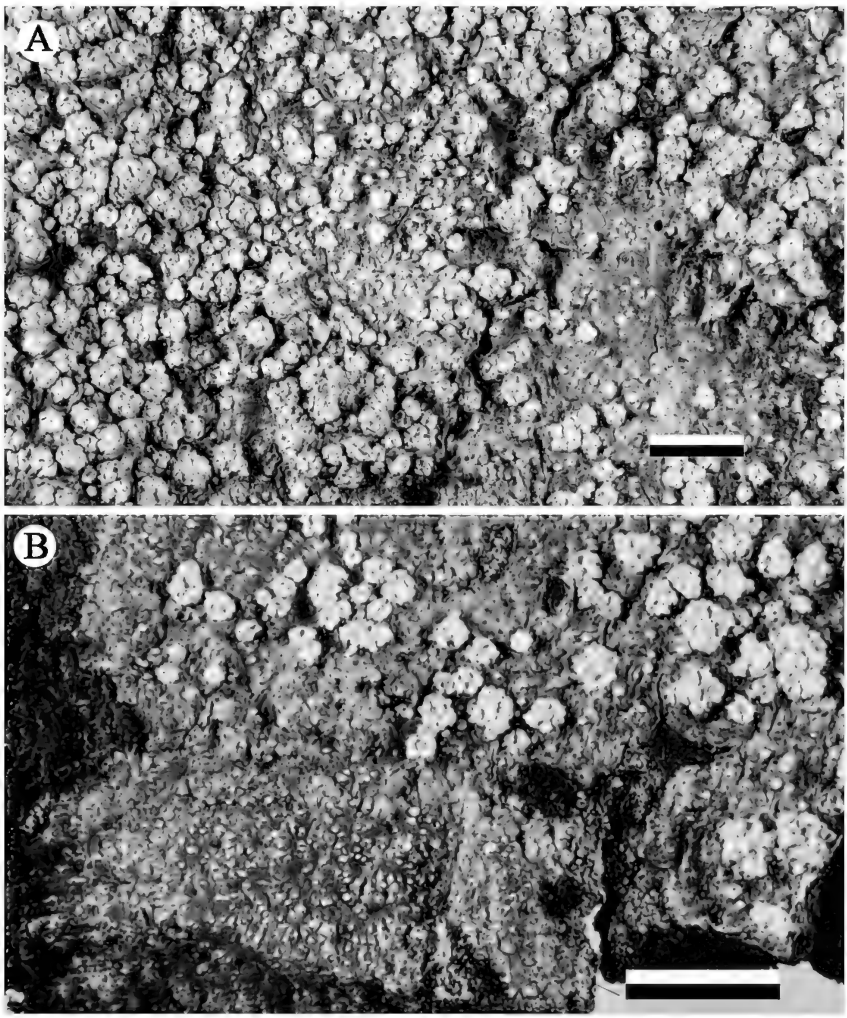

FIG. 1. *Lepra taiwanensis* (KUN – Wang 15-49266). A. Thallus with substratum, showing numerous verrucae. B. Young thallus with pseudocyphella-like verrucae. Scale bars = 5 mm.

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Validation of five *Peronospora* species names

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Abstract—Some *Peronospora* names included in the last major taxonomic treatment (a 1991 annotated list of names) were invalid because the author failed to provide the Latin description required at the time of their proposal. Here five such names—*Peronospora coronillae-minimae*, *P. erini*, *P. papaveris-pilosi*, *P. ranunculi-flabellati*, and *P. viciicola*—are validated either by providing an English description or by reference to the original English description.

Key words—biodiversity, downy mildew, *Peronosporaceae*, *Peronosporales*, plant pathogens

Introduction

Peronospora (*Oomycota*, *Peronosporales*, *Peronosporaceae*) is a species-rich genus of biotrophic plant pathogens that cause downy mildew diseases (Constantinescu 1991, Thines & Choi 2016, Salgado-Salazar & al. 2018). It is also a nomenclaturally and taxonomically complicated genus (Shaw 1981, Skalický 1983, Constantinescu 1991). Broadly, there are two approaches to describing species in *Peronosporaceae*. One approach applies a broad species concept, with one species of *Peronospora* infecting many hosts within a single plant family. The other approach applies a narrow species concept, with species having narrow host specificity (Skalický 1983, Constantinescu 1991). Molecular phylogenetic research seems to validate the application of a narrow species concept (e.g., Thines & Choi 2016), even though the

morphology of phylogenetically distinct species may overlap (e.g., García-Blázquez & al. 2008; Petrželová & al. 2017).

Constantinescu (1991) provides the most comprehensive list of *Peronospora* names and is an invaluable resource to those studying the genus. In his list, Constantinescu (1991) included many names that were invalidly published because the describing author failed to clearly designate a holotype specimen. Examples include several *Peronospora* taxa described by Gaponenko (1972), who did not designate individual type specimens, that have been recently validated by Thines (2019). Other names are invalid because the describing authors did not provide a description in Latin, which was required by the nomenclatural code in effect at the time of publication (Constantinescu 1991). The aim of this paper is to validate *Peronospora coronillae-minimae*, *P. erini*, *P. papaveris-pilosi*, *P. ranunculi-flabellati*, and *P. viciicola,* for which holotypes were designated but a Latin description was not provided. Here an English description is provided as allowed by the most recent International Code of Nomenclature for algae, fungi, and plants (Turland & al. 2018).

Taxonomy

Peronospora coronillae-minimae Vienn.-Bourg. ex W.J. Davis & J.A. Crouch, **sp. nov.**

MB 838139

"*Peronospora coronillae-minimae*" Vienn.-Bourg., Bull. Soc. Mycol. France 69: 332. 1954 [nom. inval., ICN (Shenzhen) Art. 39.1]

Conidiophores in scattered tufts on abaxial side of *Coronilla minima* leaves, emerging in clusters of 3–6, 160–200 µm long with a cylindrical or clavate trunk 8–10 µm thick. Sterigmata forming at an obtuse angle. Conidia subhyaline to pale yellow, ellipsoid, 19–32 × 16–28 µm (average: 25 × 21 µm). Oospores numerous, pale yellow, smooth wall 2.5 µm thick, 25–36 × 23–34 µm.

Type: France, Seine-et-Oise, near Ferté-Allais, *Coronilla minima* L., May 1952, G. Viennot-Bourgin, (**Holotype**, PC).

Peronospora erini Vienn.-Bourg. ex W.J. Davis & J.A. Crouch, **sp. nov.**

MB 838140

"*Peronospora erini*" Vienn.-Bourg., Bull. Soc. Mycol. France 69: 334. 1954. [nom. inval., ICN (Shenzhen) Art. 39.1]

Conidiophores scattered, hydrophilic, on margin of yellowing leaves, grayish, ragged, 80–130 µm long, 6.9 µm diam., branching in upper 1/2 to 1/3;

ultimate branchlets contracted. Conidia grey, ellipsoid, slightly apical, 12–31 × 12–21 µm (average: 24.2 × 17.5 µm). Oospores unknown.

Type: France, Hautes-Pyrénées, Cirque de Gavarnie, small bog, *Erinus alpinus* L., August 1952, G. Viennot-Bourgin (**Holotype**, PC).

Peronospora papaveris-pilosi Vienn.-Bourg. ex W.J. Davis & J.A. Crouch, **sp. nov.**

MB 838141

"*Peronospora papaveris-pilosi*" Vienn.-Bourg., Bull. Soc. Mycol. France 69: 335. 1954. [nom. inval., ICN (Shenzhen) Art. 39.1]

Forming angular, yellow–brown spots (confined by veins on *Papaver pilosum* leaves), 4.2 mm diam. Mycelium homogenous, dense, brownish, on abaxial side of the spots. Conidiophores erect, 300–400 µm long, divided, branched in upper half. Secondary branches bearing moderate to few divisions. Sterigmata forming at an acute angle. Conidia ellipsoid or globose, pale brown, 15–35 × 13–24 µm (average: 25.5 × 21.4 µm). Oospores unknown.

Type—France, Seine-et-Oise, Grignon Botanical Garden, *Papaver pilosum* Sm., April 1931, G. Viennot-Bourgin (**Holotype**, PC).

Peronospora ranunculi-flabellati Vienn.-Bourg. ex W.J. Davis & J.A. Crouch, **sp. nov.**

MB 838142

"*Peronospora ranunculi-flabellati*" Vienn.-Bourg., Bull. Soc. Mycol. France 69: 335. 1954. [nom. inval., ICN (Shenzhen) Art. 39.1]

Mycelium dense, grayish brown on abaxial side of *Ranunculus paludosus* leaves. Conidiophores variable, 300–450 µm long, branching slightly below upper half. Secondary branches distinct, flexible, branching dichotomously 1–2 times. Sterigmata short and acute. Conidia grayish brown, averaging 19 × 17.4 µm. Oospores numerous, yellowish walls, slightly pleated, 20–25 µm diam.

Type: France, Seine-et-Oise, Grignon Botanical Garden, *Ranunculus chaerophyllos* [redet. as *R. paludosus*], May 1937, G. Viennot-Bourgin (**Holotype**, PC).

Peronospora viciicola L. Camp. ex W.J. Davis & J.A. Crouch, **sp. nov.**

MB 838143

"*Peronospora viciicola*" L. Camp. [as '*vicicola*'], Bull. Wash. State Agric. Exp. Sta. 318: 18. 1935. [nom. inval., ICN (Shenzhen) Art. 39.1]

English description provided in Campbell (1935: 18).

Type: United States of America, Washington, Steamboat Rock, *Vicia gigentea* Hook. [≡ *V. nigricans* subsp. *gigantea* (Hook.) Lassetter & C.R. Gunn], 7 September 1934, L. Campbell (**Holotype**, WSP 16631).

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Typification of *Agaricus cespitosus*, *Ag. oniscus*, and *Ag. sphagnicola* and their synonymy with *Lichenomphalia umbellifera*

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Abstract—Protologue descriptions and original material of *Agaricus cespitosus*, *Ag. oniscus,* and *Ag. sphagnicola* were studied to determine the intended species concept for each. *Agaricus cespitosus* fits the second most common presentation of the current *Lichenomphalia umbellifera* and is placed in synonymy with it. *Agaricus oniscus* was created as a synonym of *Ag. cespitosus*, confirmed by its original material; therefore, it is also placed in synonymy with *L. umbellifera*, resolving problems noted with past attempts trying to apply the epithet to darker sphagnicolous species of *Arrhenia.* Careful analysis of the protologue for *Ag. sphagnicola* revealed a good fit with *L. umbellifera* but serious conflict if applied to species of sphagnicolous *Arrhenia*; it was, therefore, also synonymized with *L. umbellifera*. *Agaricus cespitosus* and *Ag. oniscus* are lectotypified with illustrations from their original material, *Ag. oniscus* is epitypified with a modern sequenced collection from Sweden, and *Ag. sphagnicola* neotypified with a K collection made by Berkeley, both identified as *L. umbellifera.*

Key words—*Omphalina ericetorum*, nomenclature, taxonomy

Introduction

> My first task would certainly be to rectify the names. … If the names are not correct, if they do not match realities, language has no object. If language is without an object, action becomes impossible—and therefore, all human affairs disintegrate and their management becomes pointless and impossible. Hence the very first task of a true statesman is to rectify the names.
>
> — The Analects of Confucius, tr. Simon Leys (1997)

In preparation for of a study of sphagnicolous species of *Arrhenia* Fr. (hereafter, sphagnicolous arrhenias), epithets applied to this group were reviewed. This revealed that some past workers have questioned the application of two epithets, *Agaricus oniscus* and *Ag. sphagnicola* to this group, referring at least the latter to the species currently known as *Lichenomphalia umbellifera.* This study was undertaken to elucidate the original species concepts for these and allied taxa.

Lichenomphalia umbellifera (L.) Redhead & al.

Over the years this species has been assigned to several genera and known by several epithets. Part of its convoluted nomenclatural history has been reviewed by Redhead & al. (2002), concluding with an argument for the current name, which has resulted in welcome nomenclatural stability. Molecular studies (Geml & al. 2012) have revealed that despite its varied appearance, in the Northern Hemisphere *L. umbellifera* is a single species, not a complex. Its mercurial nature notwithstanding, it is readily separated from sphagnicolous arrhenias, although not all characters that separate them are well known.

In the Canadian province of Newfoundland and Labrador (NL) where I live, *L. umbellifera* is ubiquitous. Between 2003 and 2016, I made 32 collections of it throughout the province, and Foray Newfoundland & Labrador (FNL, the provincial mushroom club) recorded it 73 times. Mt Ignoble, a barren hilltop less than 1½ hours on foot from our door, is the closest site where I can find it with regularity. This small lichenized omphalinoid species has very variable macroscopic appearance, its colour varying from near-white (Fig. 1A,C), ochraceous (Fig. 1B), yellowish with some purple on the stipe (Fig. 1E), and beige-tan (Fig. 1D); often the membranaceous pileus has centripetally widening bands of grey in translucent areas (Fig. 1A,B). The shape of the pileus varies from the less common convex with adnate gills (Fig. 1A,B,D,F), to markedly upturned or infundibuliform (Fig. 1C,E), with upturned edges and downsloping gills. This variation may lead one to suspect two different species, but likely the shape is related to environmental factors and age. A plane pileus with downturned edges and adnate gills is the probable result of a pileus growing freely in concert with the hymenium. Hardening of the pileipellis from exposure to sun and wind would impede its growth, and active lamellar growth would then likely produce funnel-shaped pilei with upturned (downsloping) gills. In all but the most protected moist conditions this process would be repeated over time, making the funnel shape (seen in about 70% of our collections) increasingly common as the basidiomes age. The habitat of

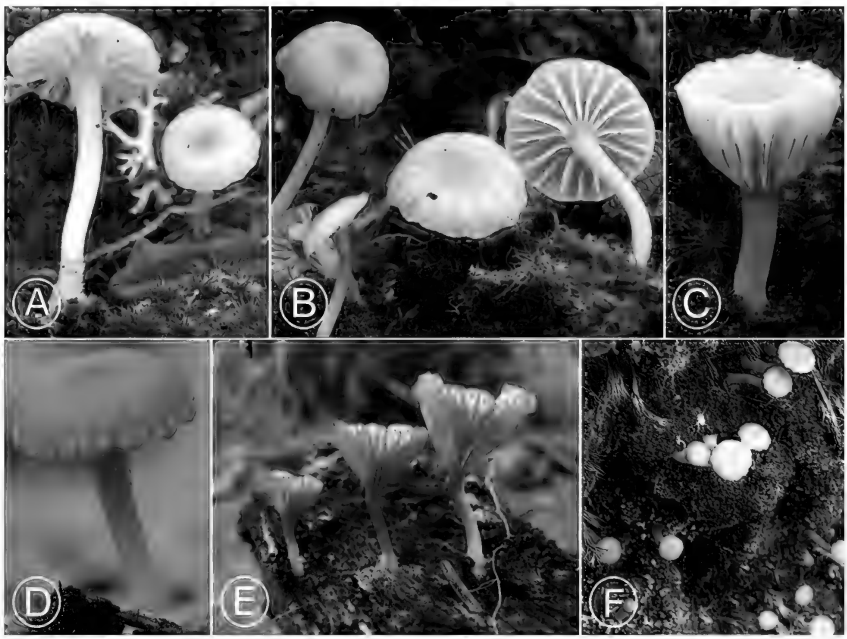

Fig. 1. A–F: *Lichenomphalia umbellifera* in NL. See text. E: Photo: Michael Burzynski.

L. umbellifera ranges from arctoalpine barrens (Fig. 1 A,D), bog (Fig. 1C), to lowland forest (Fig. 1E). It grows on a variety of substrates, earth, *Sphagnum* L. or moss, wood, with peat seemingly preferred. The species is known for two classical presentations, one resembling soldiers in a row on moss-covered rotting logs (Fig. 1E) and the other in great troops on the wet sides of peat pits (Fig. 1F).

Agaricus cespitosus Bolton

James Bolton (1735–1799) was an English naturalist whose illustrated multi-volume An history of fungusses growing about Halifax is the first English book devoted to fungi. In volume 1 Bolton (1788) describes a new species, *Agaricus cespitosus*. The description matches that of the current *L. umbellifera*, particularly the yellowish clay colour and the iconic growth in troops from the sides of peat pits. Before publishing his book, Bolton produced a six-volume pictorial record of the fungi he had encountered, with handwritten notes and aquarelles of the species. *Agaricus cespitosus* appears in volumes 1 (Bolton 1784) and 3 (Bolton 1786) with a different aquarelle in each (reproduced here as Figs 2A,B). The aquarelle from the third volume

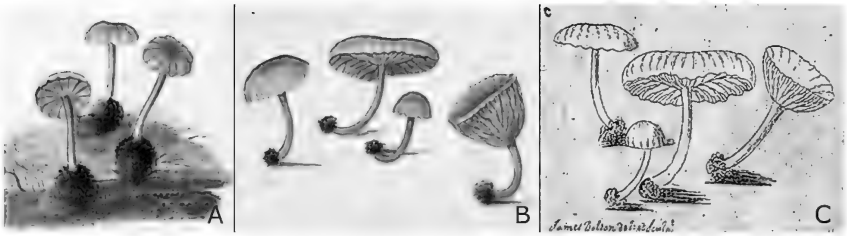

Fig. 2. *Agaricus cespitosus*: illustrations by Bolton. A: From vol 1 of his pre-publication illustrations (Bolton 1784). B: From vol 3 of the pre-publication illustrations (Bolton 1786), here declared lectotype for the species. C: The definitive illustration (Bolton 1788, tab. XLI, fig. C), cited by Fries as an illustration of *Ag. oniscus* and selected here as the lectotype for that species. Some volumes were hand coloured by Bolton; other volumes and editions were coloured by other people and various techniques. This uncoloured image was selected to avoid potential problems from differences in colouring. Images in the public domain; A & B, courtesy Special Collections, USDA National Agricultural Library; C, courtesy The New York Botanical Gardens Library.

of his Icones (reproduced here as Fig. 2B) became the basis for the copper engraving in his published work (Bolton 1888, tab. XLI, fig. C). That figure is reproduced here as Fig. 2C. No type tissue remains, making these illustrations the only available original material for lectotypification. All three illustrations are accurate representations of *L. umbellifera*, particularly the umbrella shape of radiating wedges and the representation of both convex and upturned pilei. Testing my interpretation of Bolton's formal illustration for *Ag. cespitosus*, I sent the reproduced Fig. 2C to an expert panel of mycologists familiar with arctic-alpine mycota: József Geml, Gro Gulden, Pierre-Arthur Moreau, Esteri Ohenoja, and Anna Ronikier. Each mycologist was asked what species the drawing represented, without providing a reason for the question, any suggestion of region, habitat or other information, or any potential choice of names. One panelist identified the drawing as *Entoloma sericellum* (Fr.) P. Kumm. and one as *Omphalina pyxidata* (Bull.) Quél., while three immediately concluded it was *Lichenomphalia umbellifera*. The first two were asked for the best match out of three names, *Arrhenia oniscus* (Fr.) Redhead & al., *Arr. philonotis* (Lasch) Redhead & al., *L. umbellifera*; both selected *L. umbellifera*.

Agaricus cespitosus Bolton, Hist. Fung. Halifax 1: 41. 1788.

Type: **Holotype**: unavailable. **Lectotype**: (**here designated**, MBT10004616): Bolton, *Agaricus cespitosus*, Icones Fungorum circa Halifax sponte nascientum vol. 3, p. 103, 1784, in the book held in Special Collections, USDA National Agricultural Library; [reproduced here as Fig. 2b].

= *Lichenomphalia umbellifera* (L.) Redhead & al.

Comment: Bolton's second illustration (reproduced here as Fig. 2B) is chosen as lectotype because it is the original image on which the protologue illustration (reproduced here as Fig. 2C) is based. Because both protologue, lectotype and other illustrations all fit accurately with *L. umbellifera*, *Ag. cespitosus* is placed in synonymy with it, as a later synonym.

***Agaricus oniscus* Fr.**

In his protologue of *Ag. oniscus*, Fries (1818) cited only the description and illustration of *Agaricus cespitosus* as a previous description of the same species. Fries declared that his name *Ag. oniscus* includes all other names ("et ind. univ.") and excludes—in the sense of replaces—all synonyms ("excl. omn. synon."), i.e., even the earlier *Ag. cespitosus* of Bolton. By citing only Bolton's description, and emphatically declaring Bolton's name a synonym of *Ag. oniscus*, Fries leaves no doubt about his certainty that they are conspecific. Ordinarily a later name would be declared superfluous but Fries redescribed *Ag. oniscus* in his Systema (Fries 1821), whereby the name became sanctioned, giving it precedence over Bolton's earlier *Ag. cespitosus*. Thus, application of the epithet *oniscus* should be very straightforward: in his protologue Fries stated that his species is the same as Bolton's, but because the Fries epithet became sanctioned, the species is now known as *Ag. oniscus*. Because Bolton's species is a later description of the current *L. umbellifera*, epitypified with a sequenced specimen of that species (vide supra), *Ag. oniscus* is also a later synonym of the current *L. umbellifera*.

However, confusion was instilled into this seemingly straightforward relationship by Fries himself, who in the course of the subsequent half century markedly altered his concept of the species to which he applied the epithet *oniscus*. Already three years after the 1818 protologue Fries (1821) said that since its introduction he had come to view *Ag. oniscus* as perhaps ("forsan") a variety of *Ag. cespitosus*. This is the first of progressively greater deviations that ended with Fries's application of the epithet to a taxon markedly different from the one described in the protologue. Twenty years after the protologue Fries (1838) described its originally non-decurrent gills as adnate to decurrent ("adnato-decurrentibus"), and 36 years after the protologue Fries (1854) stated that this erstwhile synonym for Bolton's turf agaric was rare in mossy and turfy habitats but common beside the sandy paths of the botanical gardens in Slottsbacken near Uppsala. Thirteen years after that Fries (1867) applied *oniscus* to a dark ("obscure") species with a convex-umbilicate to infundibuliform ("convexo-umbilicatus l. infundibuliformis") pileus, decurrent ash grey ("cinereus") lamellae, and grey ("griseus") stipe. His evolving concept had veered so much

from his early description and Bolton's species that by 1867 he was moved to offer a more characteristic image ("iconem formae typicae") of his new concept (reproduced here as Fig. 3A).

Jules Favre, the pioneer of alpine fungal ecology (Brunner & al. 2017), took this a step further, stating that Fries's 1867 illustration was too light (Favre 1948). At the time the rules governing nomenclature declared Fries's Systema of 1821 as the starting point for agaric names, denying earlier names nomenclatural priority. Favre complied with these rules and used the name *oniscus*, treated by Fries in 1821, not *cespitosus* or some earlier name cited by him. Why, then, did he not use the description of *Ag. oniscus* from the protologue, essentially duplicated in the Systema, rather opting for Fries's description of 1867, a description at odds with the original material, and clearly of a different species? We may never know the answer, but two potential contributing factors have been described to me. Pierre-Arthur Moreau (private communication) related that in 1948, French authors considered Fries's 1821 Systema a youthful work, and looked on the 1867 Monographia as the authoritative opus—so much so, that at one time French mycologists proposed that the Monographia, rather than the Systema, should be the sanctioning work for Hymenomycetes. Favre's friend and colleague, Marcel Josserand, who had great influence on Favre's tenets in these matters, was of this view. Henning Knudsen (private communication) pointed out that at the time there were very few copies of the Systema available in Europe, whereas the Monographia was common. Generally Fries remained true to his original descriptions in subsequent treatments, so that most of the time the description of a species in the Monographia did not differ significantly from the one in the Systema. Therefore, as a rule the later description could be used confidently, should the earlier one not be at hand. Whether these insights, alone or in combination, played a role in Favre's treatment of *Ag. oniscus* is a matter of speculation, but Favre did leave on record an illustration of his collection in G, including three near-black specimens (reproduced here as Fig. 3B), to depict his concept of the species.

Favre's study of Jurassic wetlands, where he treated *Ag. oniscus*, was followed by intense exploration of the alpine zone, giving him an unparalleled mastery of these mycotas. The resultant regard for his opinions helped usher in an era of applying *Ag. oniscus* to really dark species in Europe. His influence persisted until distance and time permitted Bigelow (1985), in North America 37 years later, to comment on the "discordant" fit of Favre's interpretation with Fries's protologue, stating, "Favre may not have had the same species as Fries." Indeed, rather than accepting Favre's interpretation of *Ag. oniscus*, Bigelow (1958)

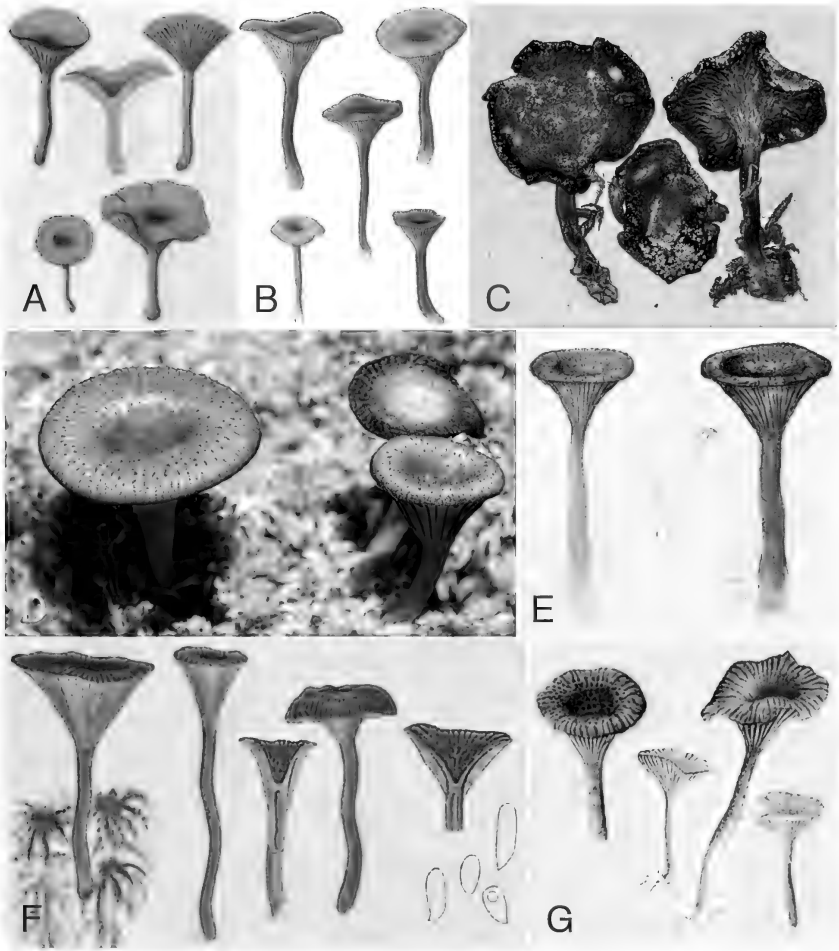

FIG. 3. Brown arrhenias, arenicolous (A), and sphagnicolous (B–G), scaly-capped (D–G, possibly C), smooth-capped (A, B). A: Fries' 1867 image of *Agaricus oniscus*, at that time considered by him to be a non-sphagnicolous arenicolous species, darker and evenly brown, significantly different from Bolton's image that Fries cited as an unquestioned synonym in 1821. Image in the public domain. B: Jeanne Favre's illustrations for Jules Favre's collections of *Omphalia oniscus* in G. Image courtesy of the Conservatoire et Jardin botaniques de Genève. C: Quélet's collection, "*Agaricus* (*Omphalia*) *oniscus* Fr" from the Juras Mountains in the E. Fries Herbarium of UPS (F-012426); seemingly sphagnicolous, but fits with a species of *Arrhenia* and not with Bolton's *Ag. cespitosus*. Photo courtesy of UPS. D: Photo of a scaly-capped sphagnicolous arrhenias in NL. E: Peck's aquarelle of the surviving of two syntypes of *Agaricus gerardianus* (NYS-1339-d). Image (I-1390) courtesy NYS. F: Jakob Lange's illustration of *Omphalina sphagnicola*. Image courtesy of Henning Knudsen, permission courtesy of Lene Lange. G: Jeanne Favre's illustrations for Jules Favre's description of *Omphalia sphagnicola*. Image in the public domain. NOTE: some of the elements on these illustrations were moved to fit space requirements, and sharpness was augmented to exaggerate scale detail beyond the original.

elected to apply Persoon's epithet *icmadophilus* (Persoon 1801) to what he thought was Fries's original *Ag. oniscus*, elevating *Agaricus epichysium* var. *icmadophilus* Pers. to species as *Clitocybe icmadophila* (Pers.) H.E. Bigelow. Redhead (1979) followed Bigelow in the use of this epithet, transferring it to *Omphalina* as *O. icmadophila* (Pers.) Redhead. Despite his justified misgivings about Favre's interpretation, 27 years later Bigelow (1985) relinquished the epithet *icmadophilus*, because he considered its protologue description "very short and could also be of several species" and justified accepting Favre's dark concept because of Fries's later volte-face to a much-altered concept of *Ag. oniscus*. Left alone using *icmadophilus*, Redhead did not make public a change of mind, but stated (personal communication) that he "acquiesced to standard usage" by 2002 (Redhead & al. 2002). This was the year *Ag. oniscus*—but not *O. icmadophila*—was transferred to *Arrhenia*[1].

Since Favre's time, rules governing nomenclature set forth in the International Code of Nomenclature for algae, fungi, and plants (henceforth the Code; Turland & al. 2018), have evolved. Before turning to the Code to reconcile conflicting opinions of which name to apply to a species first described over 230 years ago, some due diligence seems prudent to ensure that this does not produce unsuspected conflict. The following paragraphs explore whether the descriptions of *Ag. cespitosus* and *Ag. oniscus* fit with each other, whether both fit the concept of the current *L. umbellifera*, whether discordant elements in the descriptions can be reconciled with *L. umbellifera*, whether the introduction of a new name or different rankings are compatible with the synonymization, whether these descriptions fit better with sphagnicolous arrhenias, whether synonymy causes significant instability of established practice, and, finally, determine all type material available.

The descriptions of Bolton (some elements taken from his illustration) and Fries are very similar (Table 1). Bolton describes his species from the sides of peat pits, and Fries states his comes from montane heaths. The differing habitats are not mutually exclusive but indicate that Fries is not making a mechanical name change and is personally familiar with the species. He states as much in the Systema ("v. v."), where he provides mossy sites and old logs ("truncos venustos") as an additional substrate (classical *L. umbellifera* habitat/

[1] Although sometimes rendered "*Arrhenia*/*Omphalina onisca*", the somewhat counterintuitive-sounding *Arrhenia*/*Omphalina oniscus* is correct. Fries chose the noun *Oniscus*, the genus to which the woodlouse belongs; there is no corresponding Latin adjective. To make certain his intent was clear, he capitalized the epithet, as was the custom of the time for proper nouns used as epithets (e.g. generic names). A noun used as an epithet retains its gender, regardless of the gender of the genus name that it modifies.

TABLE 1. Protologue characters of *Agaricus cespitosus* and *Ag. oniscus*

	BOLTON (1788) *Agaricus cespitosus*	FRIES (1818) *Agaricus oniscus*
COLOUR	Yellowish clay	Dirty or greyish
GROWTH	Gregarious	Gregarious
HABITAT	Sides of peat pits	Montane heaths
PILEUS	Striate, translucent, smooth, 25 mm diam., convex in youth, then plane, and eventually upturned; not umbilicate unless totally upturned	Striate, translucent, smooth, 25 mm diam., convex in youth, then plane, and eventually depressed; not described as umbilicate
LAMELLAE	Distant, adnate, not decurrent (excepting the downsloping of upturned pilei).	Distant, adnate ("adnatis"), not decurrent (specifically stipulated three years later)
STIPE	25 mm high, cylindrical, usually bent to wavy	25 mm high, cylindrical, often bent, at times wavy

substrate). The only difference worthy of comment is an apparently divergent description of colour. Bolton's is "yellow clay," while Fries used "lividus," usually a lighter leaden or bluish grey, which Bigelow (1985) found "vague and difficult to visualize and reconcile". Bolton's first prepublication aquarelle (reproduced here as FIG. 4A) may provide some insight into the greys as Fries saw them. The pileus has opaque radiating lines over the lamellae and lamellulae and intervening lighter grey spaces over the thinner membranous parts. Similar narrow translucent grey wedges can be seen in membranaceous species, like *L. umbellifera* FIG. 4B, widening with age and increased hydration (FIG. 4C); both opaque and translucent parts have a greyish cast. Both Fries and Bolton saw grey in these specimens, and Bolton's description "yellow clay" was available to Fries when he declared the two names synonymous, so that the use of either colour should not be a major conflict.

Bolton's English name, peat agaric, gives away the meaning of his Latin epithet: *cæspes* is Latin for peat, and *cæspitosus* is the adjective peaty. This certainly fits with *L. umbellifera*, for which peat is a favourite substrate. Although renaming organisms already described and named was not unusual at the time, it seems likely that Fries renamed this species in the interest of clarity. In mycology, commonly the adjective *cespitosus* has been used to indicate a species with a several stipes arising from one "root". In his protologue, where he stated that *oniscus* is meant to replace all previous names, Fries did not say why he replaced the name, but emphasized that the species is gregarious yet never cespitose ("gregarius numquam cæspitosus") by making this the first sentence of the description. It is not part of the section dealing with habitat, indicating

that to Fries the adjective refers to morphology, not substrate. Having made this precision in the protologue, Fries never described *Ag. oniscus* as non-cespitose again in subsequent treatments, suggesting that this distinction was used solely to explain his reason for renaming the species. Fries spoke Latin with his father at home since childhood, wrote almost all of his books (including a layman's field guide to mushrooms!) in Latin, and carried out the vast majority of his foreign correspondence in Latin, so that he knew the language well. It may be that he sought to avoid confusion, more than to "correct" Bolton's Latin. In either case, it is reasonable to assume that he took care to select a characteristic and unambiguous new epithet.

Wood lice are common crustaceans in Sweden. Of the two genera, *Oniscus* L. and *Armadillidium* Brandt, the former are much more common, coloured various shades of grey, and do not roll up (Fig. 4D). *Armadillidium* species (pill bugs) are dark to blackish, and roll into a wheel when in danger, so that from the side the overlapping exoskeleton segments resemble the radially triangular segments of the pileus (Fig. 4E). *Armadillidium* was split from *Oniscus* in 1833, so that at the time of Fries's description both were considered *Oniscus*. Hence, the name could suggest that both the centripetally radiating triangular segments of the pill bug and the grey of the wood louse resemble the radial segments and their grey translucent areas on the pileus of *L. umbellifera*.

Fries (1821) placed *Ag. umbelliferus* L. in *Mycenaria* (with decurrent gills), and *Ag. oniscus* in *Collybaria* (with adnate gills) in his Systema. If the species treated by Fries as *Ag. umbelliferus* is the same as the current *L. umbellifera*—a subject beyond the scope of the current dissertation—then its ranking should be no impediment to accepting their synonymy. While we accord Fries's sanctioned names priority over earlier ones, we do not do the same for his taxonomy—even though he gave us our taxonomic system of ranking. Taxonomy changes constantly in response to new information, making it perfectly acceptable, for example, to place taxa in synonymy that were originally separated by gill arrangement, should new information show this to be an intraspecific, not interspecific, character. Such an outcome should not be unexpected with a synonym of the current *L. umbellifera*, which has basidiomata with both adnate and decurrent gills. Because taxonomy must remain flexible, it is an inappropriate tool for nomenclature, which aims to fix names so that they remain stable, regardless of any subsequent changes in ranking.

Fries's protologue fits well with the current *L. umbellifera*, an iconic species in montane heaths, classically fruiting in troops on old logs (Fig. 1E) in

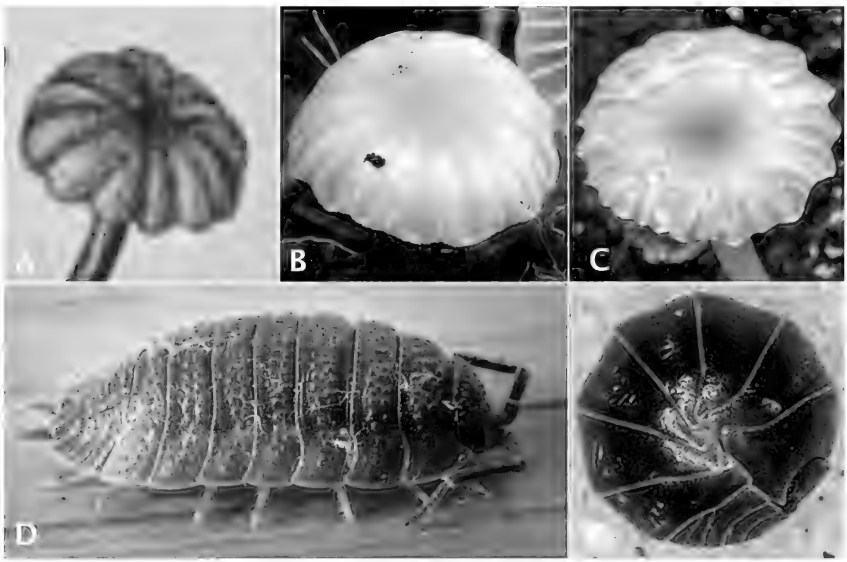

FIG. 4. Relationship of "oniscus" to pileal colour and form. A: ***Agaricus cespitosus*** (from Bolton's lectotype colour illustration). B, C: ***Lichenomphalia umbellifera*** (C: older specimen). D: ***Oniscus asellus*** L. in NL. E: ***Armadillidium vulgare*** Latreille (rolled up pill bug); Photo: Benjamin T., Wikimedia Commons, https://commons.wikimedia.org/w/index.php?curid=1936102 [Creative Commons licence CC BY-SA 3.0].

woodlands, and on the sides of peat pits (FIG. 1F). Neither Bolton's nor Fries's description fits sphagnicolous arrhenias, which grow on living *Sphagnum*, not peat, do not grow on wood (at least those species found in montane heaths), make groups of 1–6, seldom troops, very quickly develop a pronounced deep navel often without turning up the pileus, have deeply decurrent gills, and are brown or grey-brown, not whitish yellow with light grey translucent zones.

Fries provided two different descriptions for his *Ag. oniscus*. In 1818, he described a light, sphagnicolous species that does not fit a species of *Arrhenia*, and by 1867 the description had changed to a dark arenicolous, non-sphagnicolous *Arrhenia*. Applying Fries's epithet to a third species that does not fit with either of his two descriptions, namely a sphagnicolous species of *Arrhenia*, produces irreconcilable conflict with both descriptions. It seems much more reasonable to follow the Code, created to solve such matters, and a) effect a solution that avoids conflict, b) is supported by the protologue, the sanctioning treatment, and the lectotype, and c) respects Fries's uncommon degree of certainty about the synonymy of *Ag. oniscus* with *Ag. cespitosus*.

A small number of names had been applied to an even smaller number of sphagnicolous arrhenias with no apparent consistency until the work of Favre (1948). After that, most authorities, e.g., Bigelow (1985) or Redhead (Redhead & al. 2002), whether willingly or reluctantly, began to apply the name *Arrhenia*/*Omphalina oniscus*, to a dark species. Reported spore sizes for *Arr.*/*O. oniscus* by selected students of these taxa (Favre 1948, Clémençon 1982, Bigelow 1985, Breitenbach & Kränzlin 1991, Kuyper 1995, Gminder 2001, Gulden 2005, Elborne 2008) fall within a small range, 6–10 × 3.5–6 µm in size (Fig. 5). This, as well as the shared omphalinoid habitus, dark colour, and habitat suggest that these authors probably apply the epithet to the same species. However, other leading students of these taxa have identified similar species with similar spore measurements using different epithets, such as Bigelow (1985): *Clitocybe icmadophila*; Kuyper (1995): *Omphalina philonotis* (Lasch) Quél.; Lange & Lange (1982): *Omphalina epichysium* (Pers.) Quél. In addition, Orton (1960) described a dark species, *Omphalina fusconigra* Orton, with spore measurements well outside this range.

Indeed, descriptions of the species whose spore measurements are shown in Fig. 5 differ by more than their spore measurements. For example, Gulden described the dark *O. oniscus* (Fr.) Quél. as an obligate sphagnophile, whereas Favre described it as a facultative sphagnophile, a significant difference in a group with possibly narrow photobiont association. The aquarelles painted by his wife Jeannne to illustrate his collections suggest that Favre may have applied the epithet to more than one species. His collections of *O. oniscus* deposited in G are illustrated by opaque, non-striate smooth-capped basidiomes of two widely different colours, one a yellowish ochre-tan, and the other a bluish black-gray (reproduced here as Fig. 3B). The larger upper two basidiomes, one of each colour, also illustrate his interpretation of the species (Favre 1948). While different editions differ somewhat in the shading and it is possible that the light colour is due to drying, near-black and yellowish tan are an unlikely intraspecific colour variation. Finally, *Arr.*/*O. oniscus* is the most common name for sphagnicolous arrhenias in European herbaria (Robert Lücking, personal communication). This is disproportionately high for the prevalence of the species, again suggesting that the name is applied to multiple taxa.

Preliminary data from our ongoing investigation of sphagnicolous arrhenias seem to support this view: to date we have identified only one really dark species of sphagnicolous *Arrhenia* (an obligate sphagnophile, which I know well because it is relatively common in the northern part of NL) whose spore measurements (Fig. 5) match those reported by Elborne (2008). Presumably

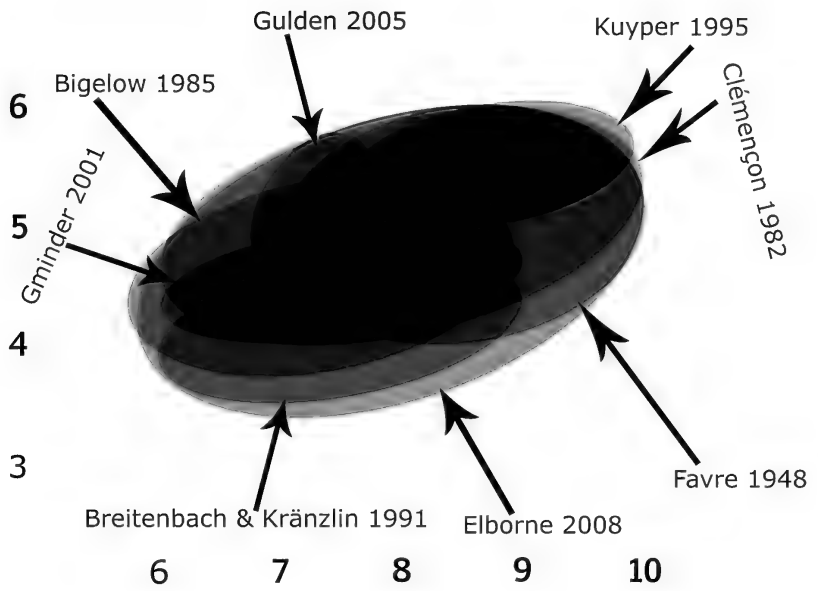

Fig. 5. Various major authors' spore measurements of *Arrhenia/Omphalina oniscus* in µm. Length on *x*-axis and width on *y*-axis.

this is the species to which the name *Arr. oniscus* is most commonly applied but, as mentioned, applying *oniscus* to facultative sphagnophiles at the same time draws other species into the concept. Thus far, our preliminary studies have found type collections of two different species in the phylogenetic clade of dark obligate sphagnophiles, so that nomenclatural consistency is lacking even here. Clearly, traditional usage is not unanimous, and any resolution will cause temporary instability to a number of collections to which the epithet has been applied. Hence synonymizing *Ag. oniscus* with the current *L. umbellifera* is less likely to cause more instability than conserving the former.

Typification as we know it today was unknown at the time of Fries, and preservation of type specimens uncommon. The only specimen in the E. Fries Herbarium of UPS identified as *Ag. oniscus* is an undated collection (F-012426) from the Juras Mountains sent by Quélet (Fig. 3C) and labelled, "*Agaricus* (*Omphalia*) *oniscus* Fr." Because Quélet was born 14 years after the protologue of *Ag. oniscus* was published, clearly this is not part of the original material. Similarly, the only illustration of *Ag. oniscus* left by Fries (1867; reproduced here as Fig. 3A) was published 49 years after the protologue, thus also not part

of the original material—in fact, markedly at odds with it. In his protologue for *Ag. oniscus*, Fries (1818) cited Bolton's copper engraving of the synonymous (as avowed by him) *Ag. cespitosus* (reproduced here as Fig. 2C). In his Systema Fries (1821) cites his 1818 protologue and Bolton's copper engraving separately. Therefore, for Fries (author of the name *Ag. Oniscus*), Bolton's illustration remains the sole de facto type material for the taxon. As we learned in the discussion of *Ag. cespitosus*, above, that image is an accurate fit for the current *L. umbellifera* (confirmed by a panel of mycologists familiar with arctic-alpine mycota) and suitable for formal lectotypification.

Agaricus oniscus Fr., Observ. Mycol. 2: 209. 1818.

Type: **Holotype**: unavailable. **Lectotype** (**here designated**, MBT10004612): Bolton, illustration in An History of Fungusses Growing about Halifax, plate XLI (41), figure C, 1788, in the book held by the library of the New York Botanical Gardens. **Epitype** (**here designated**, MBT10004614): Sweden, Jämtland, Undersåker, Trillevallen, Välliste, 63.2672°N 13.1515°E, at treeline on east slope of mountain, growing on disturbed soil. 5 July 2000, leg. Johan Rova 2501 (GB 0184058).

= *Agaricus cespitosus* Bolton

= *Lichenomphalia umbellifera* (L.) Redhead & al.

Comment: Because the lectotypes for *Ag. oniscus* and *Ag. cespitosus* depict the same gathering, the names are unavoidable synonyms and the taxa conspecific. Both have separately been found to represent *L. umbellifera*, making both later synonyms of that name. To stabilize these names, *Ag. oniscus* is epitypified with a modern sequenced Swedish specimen identified as *L. umbellifera*.

Agaricus sphagnicola Berk.

Scaly-capped sphagnicolous arrhenias (Fig. 3D) are common, yet the first description and illustration of an indisputably scaly one (Peck 1873) is *Ag. gerardianus* Peck (reproduced here as Fig. 3E). Almost 40 years earlier, Miles Joseph Berkeley, (1803–1889), a vicar and cryptogamist credited with laying the foundation to English plant pathology, described *Agaricus sphagnicola* (Berkeley 1836) as a "pale funnel-shaped agaric" with a "minutely squamulose" pileus, fruiting in *Sphagnum*. Although Berkeley's was not a description of an unequivocally scaly-capped sphagnicolous *Arrhenia*, some workers took Berkeley's word "squamulose" out of context to justify applying *sphagnicola* to such species. Lange (1937) illustrated his interpretation of *Omphalia sphagnicola* (Berk.) P. Karst. with an infundibuliform, somewhat dark and long-spored sphagnicolous species with obvious umbilical scales (reproduced here as Fig. 3F). Because Berkeley observed that "the whole plant" was "tough and elastic", and Lange specified that the species he described was

neither tough nor cartilaginous, clearly they did not apply the epithet to the same species. Indeed, Lange's species (reproduced here as Fig. 3F) is close to Peck's (reproduced here as Fig. 3E), matching scaly-capped sphagnicolous arrhenias (Fig. 3D), and not the species illustrated by Bolton (reproduced here as Fig. 2A–C). Twenty-two years later Favre (1948) followed Lange's concept, and also applied it to scaly species (reproduced here as Fig. 3G), thereby endorsing *Ag. sphagnicola* as an earlier name for a scaly-capped sphagnicolous *Arrhenia*. Some students of these species favoured one name, some the other, some used other names (e.g., *O. philonotis*, as Lange had done earlier) and some entertained two scaly-capped sphagnicolous species.

This state of affairs came to an end when Redhead (1979) reported that Berkeley's putative type collection of *Ag. sphagnicola* at K was *Gerronema ericetorum* (Pers.) Singer [= *L. umbellifera*]. He noted that the "dirty ochraceous" colour and "minutely squamulose" pileus and stipe in Berkeley's protologue have "… led many authors to believe that *A. sphagnicola* is an earlier name for *Omphalina gerardiana* (q.v.)," but concluded that the colour was well within the range of the "variable" *G. ericetorum* and attributed the reported squamules to the "deteriorated condition" of the "over mature" basidiomes. Thus, after a critical review of the protologue, Redhead was able to explain away apparent inconsistencies, and satisfy himself that Berkeley's description fit the current *L. umbellifera*. He synonymized *Ag. sphagnicola* with *G. ericetorum* [= *L. umbellifera*], and applied Peck's *Ag. gerardiana* (reproduced here as Fig. 3E) to the scaly-capped sphagnicolous arrhenias (Fig. 3D). Eight years later, with the help of Thomas Kuyper (Redhead & Kuyper 1987), Redhead discovered that the collecting label for Berkeley's putative type collection of *Ag. sphagnicola* at K did not match the date and place of the type, as noted in the protologue, and therefore, "… there is no guarantee that it represents the original *A. sphagnicola* based on a specimen collected June 21, 1827, Chartley Moss, Staffs, on *Sphagnum acutifolium* (Berkeley 1836)." This discovery led Redhead & Kuyper to state: "Currently Berkeley's species is recognized as a distinct *Omphalina*, *Omphalina sphagnicola* (Berk.) Moser, in Europe. Based on the uncertainty of the status of the specimen sent as type, the current and traditional application of the name *O. sphagnicola* is maintained."

At this time, the only published review of Berkeley's protologue (Redhead 1979) stated that it fit with *G. ericetorum* [= *L. umbellifera*]. In their report Redhead & Kuyper made no effort to re-examine the protologue, or withdraw, contradict, or amend Redhead's earlier conclusion, leaving standing the position that the protologue was a better fit for *L. umbellifera* than for scaly-

capped sphagnicolous arrhenias. Eventually Kuyper (1995) took up this question, critically reexamined Berkeley's protologue of *Ag. Sphagnicola* to conclude that it "seems to fit better for *Phytoconis ericetorum*" [= *L. umbellifera*] than *O. gerardiana* (Peck) Singer. He found no reason to alter Redhead's 1979 conclusions, rejected their joint intervening proposition to apply *Ag. sphagnicola* to a scaly-capped sphagnicolous species, resynonymized *Ag. sphagnicola* with the current *L. umbellifera*, and reapplied *O. gerardiana* to scaly-capped sphagnicolous arrhenias. This would have settled the issue, had Redhead not continued to apply *Ag. sphagnicola* to scaly-capped sphagnicolous arrhenias (Redhead & al. 2002). With the erstwhile collaborators espousing different directions, confusion reigned. Some, like I, followed Redhead's opinion, and continued applying *Ag. sphagnicola* to scaly-capped sphagnicolous arrhenias, but the lack of a type specimen, identification of at least one Berkeley collection of his *Ag. sphagnicola* as the current *L. umbellifera*, and Kuyper's analytical conclusions all added a growing number of converts to the cadre now applying *Arr. gerardiana* (Peck) Elborne to these species.

Discussions with Scott Redhead had led me to follow his practice of treating *Arr. sphagnicola* as a single scaly-capped sphagnicolous species, until our study of bog arrhenias caused me to review the names and protologues of this group and discover a vexing quagmire of discontent. Without type material, the protologue, now the only source of a species concept, assumes even greater importance in guiding the selection of new type material to fix the name. Kuyper's interpretation could only be tested by repeated analysis of Berkeley's description. While Kuyper had already done this, he published his conclusion only and not the methodology or step-by-step analysis so that the reader could judge the validity of his conclusions. I decided to suspend my own belief that *Ag. sphagnicola* represents a scaly-capped sphagnicolous *Arrhenia* and test Kuyper's interpretation by analyzing each of Berkeley's key characters, one by one. In NL, *Lichenomphalia umbellifera* is relatively common, and because I am fond of its preferred habitats, I have encountered it often. Over 20 seasons I had accumulated many collections from various areas of the province, with 31 photos of 21 collections. My plan was to review these 31 photos for the presence or absence of each key character in Berkeley's protologue.

The strength of this approach is objectivity: these photos were taken at a time when I used *Arr. sphagnicola* for scaly-capped sphagnicolous arrhenias and was unaware of any controversy suggesting *Arr. sphagnicola* might be conspecific with *L. umbellifera*. Photos were not taken to prove a point or demonstrate the presence or absence of any specific characters, but merely

to document a collection. The weakness of this approach is that a photo that documents a collection in a general way may not always reveal specific distinguishing characters, and critical parts may be omitted or out of focus. Thus, even with 31 photos to choose from, the odds are skewed slightly against identifying characters of *Ag. sphagnicola* on these photos; finding Berkeley's key characters under these conditions should constitute objective proof of their presence in *L. umbellifera*. Discussion of each key character described by Berkeley follows.

Basidiome: tough and elastic. This character is not visible on photos, of course, but is so significant it must be included: with this feature Berkeley immediately eliminates the friable scaly-capped sphagnicolous arrhenias as possible candidates for his epithet *sphagnicola*. For this reason Bigelow (1958) stated that *C. gerardiana*, which he described as "always soft and fragile", "cannot be considered identical with *Ag. sphagnicola* Berk." Redhead (1979) concurred, saying Bigelow "quite rightly pointed out" this incompatibility. This character fits only with *L. umbellifera* and encounters a major and irreconcilable conflict if applied to scaly-capped sphagnicolous arrhenias. Just as with Lange's interpretation, the discussion is really over before we even begin to look at images. The method I chose serves only to examine how well other macroscopic characters support this conclusion.

Pileus: dirty ochraceous. Berkeley's English name for his species was "pale funnel-shaped agaric". In common usage, "light" indicates less intense or diluted pigmentation (e.g., light blue), whereas "pale" indicates paucity or lack of pigmentation (e.g., to become pale). *Lichenomphalia umbellifera* does not have much colour, ranging from white through (dirty) yellow to nearly mid-tan on occasion (Figs 1, 6). The Oxford English Dictionary renders ochraceous as a pale hue. Both pale and dirty ochraceous fit the dingy yellowish *L. umbellifera*. In contrast, scaly sphagnicolous arrhenias are brown and patterned, with alternating radial stripes of light or dark brown. Both pale and dirty ochraceous would be inexact terms to describe them. The colour fits much better with *L. umbellifera* than sphagnicolous arrhenias.

Pileus: becoming darker with age. Most of the darkening of *L. umbellifera* occurs at the pileus rim and lamellar edges (Fig. 6B–D, M), which show through the pileus due to its lighter hue and translucency. Sphagnicolous arrhenias darken in a similar manner, and very occasional specimens undergo an uncommon darkening reaction, not unlike that observed in the two smaller specimens on Fig. 6A. Becoming darker with age fits with both *L. umbellifera* and sphagnicolous arrhenias.

Pileus: infundibuliform. Variations of the infundibuliform shape (Fig. 6A–J, L), with upturned pileus, deep navel, and downsloping gills, are the most common presentation for *L. umbellifera*, seen in at least 70% of NL basidiomes. Scaly-capped sphagnicolous arrhenias develop navels and decurrent gills, also assuming a funnel shape, although usually with a broader angle. "Infundibuliform" fits both *L. umbellifera* and an *Arrhenia* species.

Pileus: funnel-shaped from a very early stage of growth. Early disproportionate hymenial development relative to pileus growth gives the cap-gill structure of immature *L. umbellifera* a triangular shape with an early navel, leading to the funnel-shape (Fig. 6E–I). Hymenial growth occurs later for arrhenias, which usually emerge as small discs with inturned edges and hypoplastic gills, becoming umbilicate later in development. Early funnel shape fits much better with *L. umbellifera* than sphagnicolous arrhenias.

Pileus: faintly striate. Because all tissues are a light colour with little contrast, striations of *L. umbellifera* are faint (Fig. 6A, H–L). Sphagnicolous arrhenias with their incrusted pigment usually have markedly striate pilei. Faintly striate fits much better with *L. umbellifera* than sphagnicolous arrhenias.

Lamellae: thick, with a flat edge, dirty ochraceous. Lamellae of both *L. umbellifera* (Fig. 6A–D, L, M) and sphagnicolous arrhenias are thick, with flat edges, but only those of the former are ochraceous. Thick, ochraceous lamellae fit much better with *L. umbellifera* than sphagnicolous arrhenias.

Stipe: on *Sphagnum*, adhering by its downy base. When *L. umbellifera* grows in *Sphagnum*, its stipes usually seem instititious because they are enveloped in *Sphagnum* (Fig. 6A–C), and at times a white mat of mycelium is evident (Fig. 6A,B,M) but if teased out, a more prominently downy white base can be seen (Fig. 6A,D–F). Sphagnicolous arrhenias also adhere to *Sphagnum* but have a more easily seen downy base. Adherence to *Sphagnum* and a downy base is present for both but may need seeking out with *L. umbellifera* more than with sphagnicolous arrhenias.

Stipe: nearly impervious, hollow. The protocol could not be followed to examine the integrity of stipe context on my photos, because I had never cloven the basidiomes to photograph stipe core. The basidiomes are so small that sagittal bisection is inconvenient, and *L. umbellifera* is so readily recognizable macroscopically that I had no reason to seek an additional character for identification, particularly one of questionable value, given that so many good field mycologists had already documented it as either partly (subfistulosus; Fries 1815) or totally (Cooke 1883, Peck 1893, Bigelow

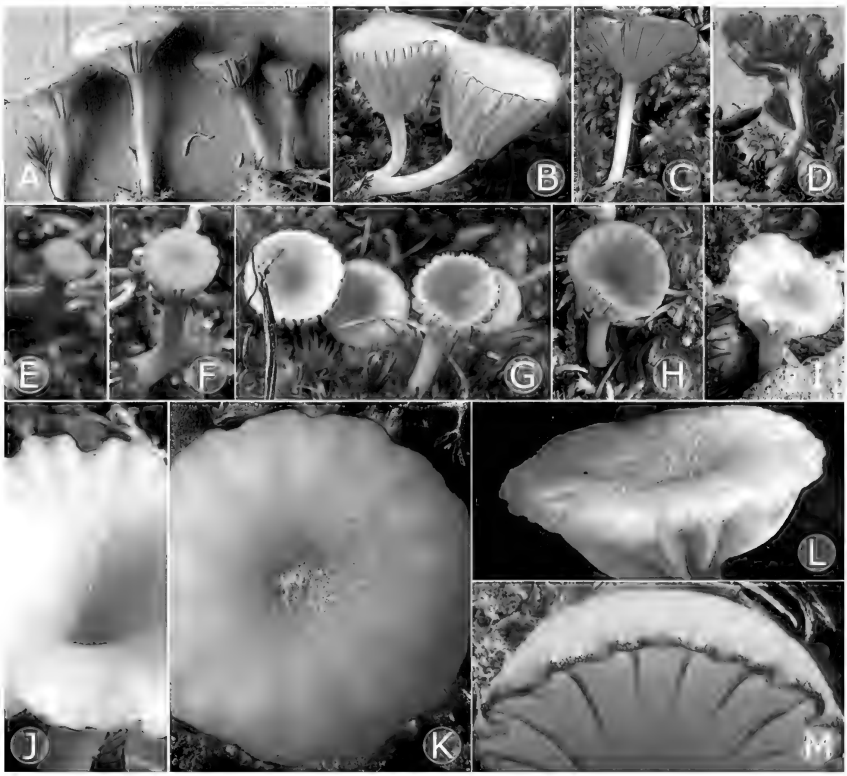

Fig. 6. *Lichenomphalia umbellifera:* characters of basidioma, pileus and lamellae. Dirty, ochraceous pileus: A, G, I K, L. Darkening with age: B, C, D, M. Pileus infundibuliform: A–J, L. Pileus funnel-shaped early: E–I. Pileus faintly striate: A, H–L. Lamellae thick with flat edge, dirty, ochraceous: A–D, L, M. Pileus minutely squamulose: J–M.

1970, Breitenbach & Kränzlin 1991) hollow. Except for one collection that I could not locate, the package containing all my *L. umbellifera* collections sent for sequencing was lost in the mail on return. Thus, I had no voucher tissue to examine. However, I had just returned from a collecting trip to Great Caribou Island in Labrador (Voitk & Burzynski 2018), where *L. umbellifera* is copious. Although participants had been asked to focus on other groups and not "waste time" on *L. umbellifera*, six collections of the species had been made. Of these six dried collections, one had stuffed stipes, one had partly hollow ones, and four had obviously hollow stipes (Fig. 7G–K), one of them impervious (Fig. 7G), and the other nearly so (Fig. 7H). Just in case the drying process converts stuffed stipes to hollow, I decided to examine my next

finds in situ. The very first fresh specimen I found after that also had a hollow stipe (Fig. 7I). All these specimens were mature, making it possible that stipes of younger specimens may not be hollow. However, this is moot: finding six out of seven consecutive random collections with hollow stipes, thereby supporting similar observations by several respected mycologists (vide supra), confirms that a hollow stipe fits with *L. umbellifera* and, therefore, is not a useful differentiator for these taxa.

Stipe: very minutely squamulose. This is the key to unravelling Berkeley's meaning of the scaliness of his taxon, and therefore deserves detailed attention. Redhead (1979) quite correctly observed, "The presence of squamules on both the stipe and pileus is certainly unusual for any Omphaloid species from bogs." In 20 years of surveying bogs and examining several hundred basidiomes of *L. umbellifera* and sphagnicolous arrhenias, I have yet to see one of either with a scaly stipe. Redhead's (1979) explanation that such scaliness might be due to an "over mature" specimen, whose "deteriorated condition may explain the reported squamules" contradicts Berkeley's description of the stipe as "… smooth, except at first, when it is very minutely squamulose …" In other words, the ornamentation described by Berkeley was not the result of age and deterioration, but something observed in young healthy basidiomes. Redhead did not describe scales from his examination of the "type" collection, but merely referred to them as "reported squamules," suggesting that such scales were reported by Berkeley, but not seen by him. This strongly suggests that to Berkeley "very minutely squamulose" meant something other than obviously scaly.

To understand what exactly Berkeley means, it helps to know that he was a cryptogamist and active microscopist, to whom observing and recording features best seen with magnification was second nature. As a vicar he likely also had a good understanding of the English language, with an ability to use words accurately and precisely. Employing four levels of diminution, he could not be more emphatic that he is not describing an obvious scaliness like that seen on scaly-capped sphagnicolous arrhenias (Fig. 3D), but something much more subtle.

1. He does not say squamous/squamose, but uses the diminutive, squamulose.
2. He does not stop at squamulose but specifies minutely squamulose.
3. "Minute" is not small, but extremely small.
4. The diminutive scales of the stipe are not extremely small, but very extremely small.

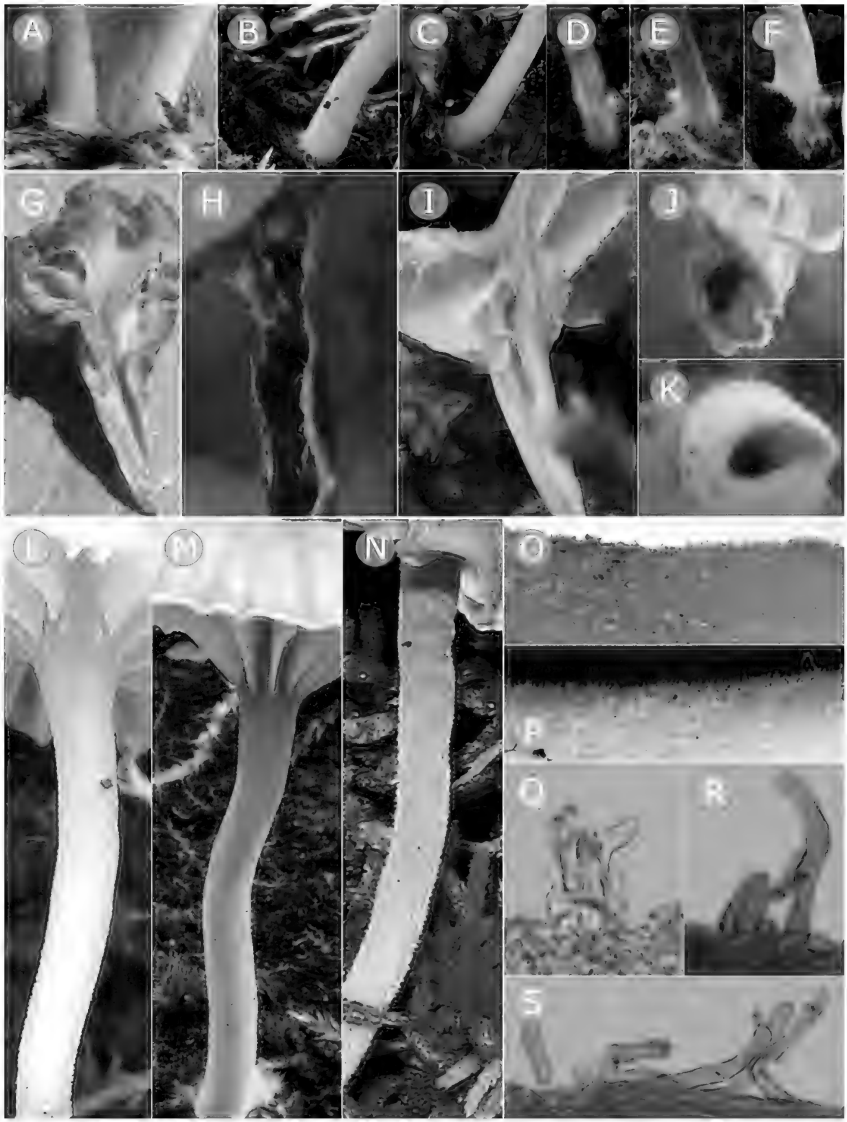

FIG. 7. *Lichenomphalia umbellifera:* stipe characters. Stipe on *Sphagnum*, adhering by downy base: A, B, D–F, M. Pileus hollow: G–K. Pileus impervious or nearly so: G, H. Stipe very minutely squamulose: L–P. Microscopic view of very minute squamules: Q–S. M courtesy of Michael Wood and N courtesy of Leif Stridvall.

Scientific writing is bare and dry. Use of modifiers is not capricious, but intentionally reserved only to convey important descriptive information. Thus, in the term "squamulose stipe," stipe is taken for granted, and squamulose becomes the important word, distinguishing this stipe from both glabrous and squamose ones. It is even less common to modify a modifier, only justified if the second modifier conveys even more important descriptive information. In the term "minutely squamulose stipe" the most important descriptive information is conveyed by "minutely": the extremely small size of the stipe adornments serves to distinguish these stipes from merely squamulose ones.

However, the addition of "very" to exactly the same words that Berkeley used earlier to describe pileal ornaments, does not serve to distinguish these stipes from other stipes, but rather to indicate that the ornamentation is similar on both pileus and stipe, save for size. Size, of course, is relative, but generally scientific writing relates size of parts to the primary structure described (unlike romantic poetry, which relates everything to the author). Hence, very minute stipe squamules are very minute in relation to the size of the stipe, not the size of Reverend Berkeley. On a stipe described as a little over 2 mm wide, scales of sphagnicolous arrhenias, which may approach a width of 0.25–0.5 mm at their base (i.e. 12–25% of the stipe diameter), would be unlikely to be considered small, let alone extremely small. On the other hand, stipe adornments of the near-microscopic scale suggested by the above interpretation of Berkeley's description would fit. Such adornments have been described before for the current *L. umbellifera*. Peck (1893) stated that the stipe of *Omphalia ericetorum* (Pers.) S. Lundell [= *L. umbellifera*] "may be either glabrous, pruinose or hairy-squamulose", and Bigelow (1970) described the stipe of *Omphalina ericetorum* (Pers.) M. Lange [= *L. umbellifera*] as pubescent in his key, and observed that it was "sometimes pubescent above, if deeply embedded in wet moss". Perusing Internet images of *L. umbellifera*, reveals several with textured stipes. Figure 7 shows two examples, one from California, photo: Michael Wood (Fig. 7M), and one from Sweden, photo: Leif Stridvall (Fig. 7N).

A search for stipe texture on my photographs proved rewarding. As suspected at the outset, on photos meant primarily to record collections, most stipes lacked adequate focus, sufficient resolution, or both, to permit satisfactory magnification, but magnification and focus enhancement of the best-focussed stipes confirmed that at close range the texture was irregular, not smooth (Fig. 7L). To examine the nature of this vestiture, I collected some

fresh specimens of "normal" (in the sense that their stipes appeared glabrous to the naked eye) basidiomes. Macro lens photos revealed that their vestment varied from finely tomentose (Fig. 7P) to wider projecting ornamentation (Fig. 7O). Microscopical examination revealed that the stiptipellis consisted of longitudinally arranged hyphae. Tufts of 4–6 or more round-ended hyphae, originating below and parallel to the superficial longitudinal layer, made a sharp right-angle turn to project through it for a length of 30–50 µm or more, and sometimes then bent to run parallel with the stipe on the outside (Fig. 7Q, longitudinal section, and Fig. 7R,S, transverse section). The observed adornments fit Berkeley's words accurately, similar features have been described by several experienced field mycologists, and—most importantly—no valid alternate interpretation exists to explain Berkeley's "very minutely squamulose" stipe. The only available explanation is that Berkeley was precise with his use of words and took great pains to say exactly what he meant; attempts to impose other meaning on these words have proven misleading.

Significantly, Berkeley used different words to describe stipe texture of sphagnicolous arrhenias. The only other time he used exactly the same words, "very minutely squamulose" to describe stipe ornamentation was to describe the stipe of a specimen of *Ag. umbelliferus* [= *L. umbellifera*] he found on a mud wall (Berkeley 1836). Because we know that *L. umbellifera* does not have a "scaly" stipe in the common meaning of the term, we now have proof that Berkeley must mean something other than scaly with those words. Of course, it does not escape the reader that conspecificity is one possible reason for two specimens (e.g., *Ag. sphagnicola* and *Ag. umbelliferus* in Berkeley's treatment) to have similar characters.

This detailed analysis of Berkeley's words, combined with detailed morphological examination of the stiptipellis, does not strive to show that *L. umbellifera* differs from sphagnicolous arrhenias in this regard. So many characters in Berkeley's protologue fit *L. umbellifera* better than sphagnicolous arrhenias that there is no need to for lengthy analysis to document additional differences. The purpose of this detailed analysis is, instead, to provide a parameter for interpreting Berkeley's "minutely squamulose" in his description of the pileus of *Ag. sphagnicola*.

Pileus: minutely squamulose. Discussion of this character—the very character from which former misinterpretations of this species stem—was moved here, because, as mentioned above, knowing what is meant by the "very minutely squamulose" stipe makes it easy to understand what is meant by the "minutely squamulose" pileus. Describing surface adornments of both

stipe and pileus with exactly the same words indicates that the appearance of the pileus texture is similar to that of the stipe, differing only by a slight increase in size. Squame is scale, squamule is a little scale, and a minute squamule is an extremely small little scale. Berkeley describes the stipe vestiture as a VERY extremely small little scale, i. e. something bordering on the microscopic, fitting FIG. 7L–Q. Given this standard—and no alternate demonstration of scale vestiture for stipes of sphagnicolous arrhenias is available—the extremely small little scale (without "very") of the pileus fits the range shown by FIG. 6J–M, which is well out of the range of the scales on scaly-capped sphagnicolous arrhenias (FIG. 3D–G). Hence, Berkeley's description of cap ornamentation fits very well with *L. umbellifera*, e.g., FIG. 5M, but presents a significant conflict with its application to a truly scaly sphagnicolous arrhenias, e.g., FIG. 3C–F.

The appeal of the above review is that all characters in the protologue for *Ag. sphagnicola* can be verified in specimens of *L. umbellifera*—including the stipe and pileus vestiture, something that has eluded previous attempts. Redhead's 1979 and Kuyper's 1995 opinions are confirmed: the protologue of *Ag. sphagnicola* fits better with *L. umbellifera* than with scaly-capped sphagnicolous arrhenias. It only remains to assess whether acting on this would upset the nomenclatural stability of established practice.

Current and traditional application

Redhead & Kuyper (1987) referred to Moser's *Omphalina sphagnicola* (Moser 1967), when deciding to maintain "current and traditional application" of the name *sphagnicola*. Moser's usage may have been current in central Europe twenty years earlier, but certainly not universally so. By choosing a new name, Peck (1873) became the first to reject *Ag. sphagnicola* as a fitting name for a scaly sphagnicolous *Arrhenia*. In the margin of his early hand-written notes of *Ag. gerardianus*, he wrote, "Is this *Ag. affricatus*" (FIG. 8), clearly indicating that he considered earlier descriptions and names—surely including *Ag. sphagnicola*—before concluding his to be an undescribed species. Bigelow espoused the use of *Ag. gerardianus* for a scaly sphagnicolous *Arrhenia*, thereby enrolling more adherents to this practice. Redhead's 1979 declaration that *Ag. sphagnicola* was a later synonym for *G. ericetorum* [= *L. umbellifera*] persuaded more mycologists to abandon applying *Ag. sphagnicola* to sphagnicolous arrhenias. After Kuyper (1995) examined the protologue of *Ag. sphagnicola*, synonymized it with *Phytoconis*

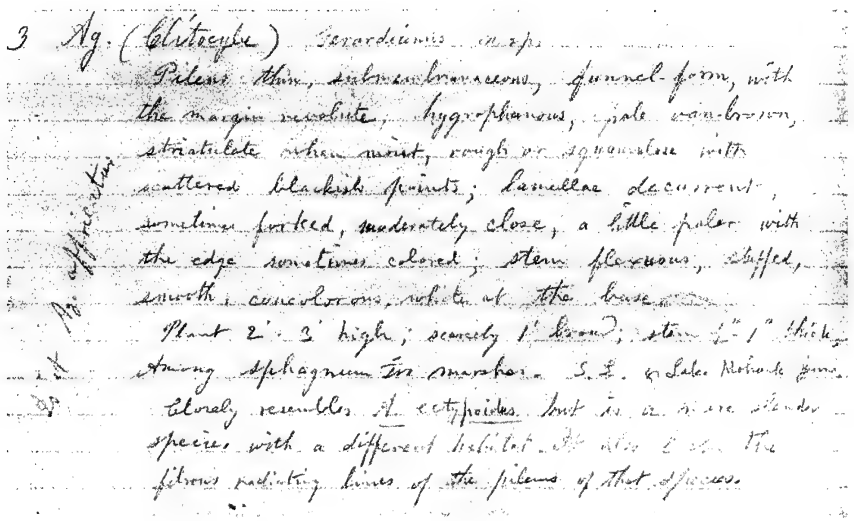
3 Ag. (Clitocybe) Gerardianus n. sp.
Pileus thin, submembranaceous, funnel-form, with the margin revolute, hygrophanous, pale van-brown, striatulate when moist, rough or squamulose with scattered blackish points; lamellae decurrent, sometimes forked, moderately close, a little paler with the edge sometimes colored; stem flexuous, stuffed, smooth, concolorous, white at the base.
Plant 2'-3' high; scarcely 1' broad; stem 1/2"-1" thick.
Among sphagnum in marshes. S. L. & Lake Mohawk June.
Closely resembles A. ectypoides but is a more slender species with a different habitat. It also [illegible] the fibrous radiating lines of the pileus of that species.
Is it Ag. affricatus

FIG. 8. Photo of Peck's handwritten note made of the syntype from Sand Lake of *Agaricus gerardianus* at NYS. The specimen has been missing, but the note remains. Note margin note—"Is it *Ag. affricatus*"—proof that Peck considered older names and descriptions, before deciding this was a new and hitherto undescribed species.

ericetorum (Pers.) Redhead & Kuyper, and applied *O. gerardiana* to scaly-capped sphagnicolous arrhenias, even more mycologists followed this usage. Significant headway was made after Elborne (2008) accepted Peck's *Ag. gerardianus* as the correct name for scaly-capped sphagnicolous arrhenias, transferring it to *Arrhenia*. Favre (1948) had followed Lange and used *O. sphagnicola* for scaly-capped arrhenias, synonymizing it with *O. gerardiana*. He pointed out that Singer also supported this but stated that Singer synonymized it with *O. philonotis* instead. Such inconsistency in the interpretation of *Ag. sphagnicola* among authors applying it to scaly-capped arrhenias may have contributed further to the increasing support to abandon the application of *Ag. sphagnicola* to sphagnicolous arrhenias.

Although it is difficult to measure "current and traditional application" accurately, changes over the last four decades suggest that synonymizing *Ag. sphagnicola* with the current *L. umbellifera*, will be no more disruptive than applying it to a scaly-capped *Arrhenia*. In such a situation a decision made in accordance with the Code has the advantage of more effective contribution to future stability.

Agaricus sphagnicola Berk., The English Flora, vol. 5(2): 67. 1836.

TYPE: **Holotype**: unavailable. **Neotype (here designated**, MBT10004615): UK, Kew Gardens, K(M)25223, identified as *Agaricus sphagnicola* by Berkeley and revised as *Gerronema ericetorum* by Redhead (1979: p. 339; A study of the sphagnicolous fleshy *Basidiomycetes* in the eastern sections of the Canadian boreal forest. PhD thesis, University of Toronto).

= *Lichenomphalia umbellifera* (L.) Redhead & al

COMMENT: To avoid further debate and stabilize nomenclature, the name is neotypified with a specimen identified as *L. umbellifera* by Redhead (1979). This synonymy agrees with Kuyper's opinion, confirmed here, and is in keeping with the direction of current practice over the last four decades.

Discussion

The universe with all its contents, including various fungi, is "real" and can be "observed" (Mann 2012). Such observations are fact. In contrast, our interpretation of the world around us, even if based on observed fact, is not fact, but opinion. Taxonomy, our system of ranking organisms based on their presumed evolutional relationship, is not a fact found in the universe, but a philosophical construct made by us in an effort to understand and explain the world we observe. Taxonomy is in constant flux, ever changing as new information becomes available. Initial ranking was based on macroscopic appearance. Once observations of distribution, habitat, substrate, and ecology were seen to separate some organisms from others, ranking changed in some cases. The ability to observe microscopic morphology brought about significant taxonomic changes. Ability to analyze chemical composition, and performance of mating studies contributed to further ranking changes. Our recent ability to determine DNA sequences cheaply and accurately has introduced a major revolution in taxonomy. Among other things, molecular studies have allowed us to recognize species complexes (several separate species, previously considered one because they look alike), e.g., morels (Richard & al. 2015), on the one hand, and plastic species ("true" single species, previously suspected to be several because of their protean nature), e.g., *L. umbellifera* (Geml & al. 2012) on the other.

Species, the lowest ranked units of taxonomy, are identified by unique epithets, which stay the same, regardless of how their taxonomic position may change. One of the main reasons nomenclature has been successful is that its epithets replace the diverse regionalism of common names with a stable nomenclature, fixed across the globe by typification governed by the Code. Lack of typification permits various interpretations of descriptions and

illustrations by different authors, at times leading to a situation no better that the earlier common names. A few years back, within one week I got two letters about one species that began, "Our Nordic interpretation of species X…" and "The Iberian interpretation of species X…." Needless to say, species X was a non-typified species. The more complicated our system becomes, and the more rapidly knowledge that alters taxonomy advances, the more important it is that names identifying individual organisms remain firmly fixed. In the interests of more reliable data, many scholarly publications no longer accept ITS analysis alone, but require multilocus analysis of sequenced species, yet these same publications regularly present works treating untypified species. With due respect I submit that it is not the lack of DNA that makes a species concept a mere rumour, but the lack of typification.

The Code has been established and continuously refined to help new typification where type material is unavailable. Determining correct application of names requires interpreting old descriptions, not always easy because these are often brief, vague and ambiguous (e.g., the epithet *icmadophilus*). Fortunately, the descriptions of *Ag. cespitosus*, *Ag. oniscus*, and *Ag. sphagnicola* are lucid, and the first two have readily identifiable original material suitable for typification. Words need very careful interpretation, in context, as demonstrated by the case of *Ag. sphagnicola* to seek an accurate fit for typification. The use of old names is desirable: it respects earlier workers and reduces the clutter of orphaned names clamouring for adoption. Placing names in synonymy also reduces clutter and seems more respectful than their willful use contrary to the original author's intent.

The treatment of our three species can be capsulated as follows:

1. *Agaricus cespitosus*. This is a later synonym for the current *L. umbellifera*. No other species has a convincing or congruent fit with the protologue and lectotype, an opinion verified by an expert panel.
2. *Agaricus oniscus*. Fries expressed uncommon certainty that the species is synonymous with *Ag. cespitosus*, citing its illustration as the only de facto lectotype. We have formalized his intent by declaring it so. The current (and retroactive) Code condones change in the description of a species—whether by the author or another—only if it is supported by the original material. In this case Fries's later description and illustration (Fig. 3C) must be dismissed because one is not supported by the protologue, and the other is entirely dissimilar from the lectotype (Fig. 2C). Because *Ag. cespitosus* is a later name for the current *L. umbellifera*, *Ag. oniscus* is also a later synonym for the current *L. umbellifera*.

3. *Agaricus sphagnicola*. The protologue does not support applying this name to scaly-capped sphagnicolous arrhenias but fits with the current *L. umbellifera*. This view concurs with two past assessments (Redhead 1979, Kuyper 1995), and is strengthened by the fact that at least one specimen identified by Berkeley as *Ag. sphagnicola* has also been identified as the current *L. umbellifera* (Redhead 1979). *Agaricus sphagnicola* is another later synonym for the current *L. umbellifera*.

To prevent undue disruption, the Code provides for a mechanism to fix names in accordance with past practice. However, if this has been diverse and inconsistent, as with *Ag. oniscus* and *Ag. sphagnicola*, stability is best served by fixing names with the best match to the protologue and original material that avoids conflict. Conserving a name erroneously applied only for a segment of its application at the expense of displacing names of sequence-confirmed synonyms with better fit offers little advantage to stability, especially over solutions that select names fitting with the original material. A poor fit accepted to-day may become tomorrow's invitation for retypification, thus serving short term stability only. No doubt future technologies will continue to refine the accuracy of our nomenclature and taxonomy, but familiarity with the species is unlikely to go out of fashion, whatever its nom du jour.

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New records from Turkey: *Cortinarius barbatus*, *C. osmophorus*, & *C. saturninus*

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Abstract—Three *Cortinarius* species, *C. barbatus*, *C. osmophorus,* and *C. Saturninus,* have been identified as new records for the Turkish mycota based on macro- and micromorphological characters, and their identifications were supported by molecular (rDNA ITS) phylogenetic data. The Turkish specimens are illustrated, and their diagnostic characters are compared with published descriptions of the same species and related taxa.

Key words— *Agaricales*, *Cortinariaceae*, Eastern Anatolia, Bingöl, Bitlis, Hakkâri

Introduction

Cortinarius (Pers.) Gray is a taxonomically complex genus of *Cortinariaceae* that shows a high degree of morphological variability (Liimatainen 2013). Morphological characters include a convex (often umbonate) smooth pileus, emarginate to adnate lamellae, brown to rusty brown ornamented basidiospores, and a cobweb-like partial veil attaching stipe and pileus (Ammirati & al. 1985, Hoiland & Holst-Jensen 2000). The two most diagnostic characters of the genus are the presence of a cortina (partial veil) between the pileus and the stipe and rusty brown spores (Kirk & al. 2008, Uzun & al. 2013).

Cortinarius is the largest genus of ectomycorrhizal fungi, distributed worldwide in temperate areas, coniferous forests, and arctic and alpine tundra (Brandrud & al. 1990–2018). Many *Cortinarius* species are endemic, probably due to climatic and edaphic factors (Garnica & al. 2005; Stefani

& al. 2014). The many cryptic taxa within the genus complicate species identification (Niskanen & al. 2013). The varying interpretations of morphological characters among mycologists often cause disagreements over species concepts (Liimatainen 2013), which has produced a proliferation of synonymous species names within the genus.

Most researchers have used molecular markers to support their species identification (Garnica & al. 2003, 2005, 2009; Peintner & al. 2003; Frøslev & al. 2005, 2007; Ortega & al. 2008; Liimatainen & Niskanen 2013; Stensrud & al. 2014; Stefani & al. 2014; Liimatainen & al. 2017; Sesli & Liimatainen 2018). Garnica & al. (2005) and Frøslev & al. (2007) showed that the rDNA ITS region is a particularly useful marker for species level identification for *Cortinarius*.

The literature (Sesli & Denchev 2014; Akata & al. 2015; Güngör & al. 2015; Sesli & Moreau 2015; Sesli & al. 2015, 2016; Sesli 2018; Sesli & Liimatainen 2018; Acar & Kalmer 2018; Kalmer & al. 2019) has reported 116 *Cortinarius* species from Turkey.

Three additional *Cortinarius* species—*C. barbatus*, *C. osmophorus*, *C. Saturninus*—reported as new for Turkey and supported by morphological characters and molecular data are described below.

Materials & methods

Taxon sampling and morphological studies

Cortinarius samples were collected from Turkey's Bitlis, Hakkâri, and Bingöl provinces in 2018. During fieldwork, specimens were photographed with a Canon (EOS 60D) camera equipped with a Tokina 100 mm macro lens. Macroscopic characters (pileus, stipe, lamellae, and cortina) were recorded from fresh materials. Measurements were made of at least 50 spores and 20 basidia and cheilocystidia from two samples of each specimen. Sections were mounted in distilled water, congo red, and 3% KOH solution for examination of spores, basidia, basidiospores, and marginal cells under a Leica EZ4 stereo microscope and tissues under a Leica DM500 research microscope. Measurements were made using the Leica Application Suite (version 3.2.0) programme and identified according to *Cortinarius* literature (Lange 1938; Zerova & al. 1979; Arnolds & Kuyper 1995; Phillips 2006; Frøslev & Jeppesen 2008; Brandrud & al. 2012, 2014; Liimatainen & al. 2014; Soop 2018). Specimens were deposited in the Fungarium of Van Yüzüncü Yıl University (VANF).

Molecular studies

Genomic DNA was extracted from dried basidiomata using the CTAB method (Doyle & Doyle 1987). The purity and quantity of extracted DNA were determined by using NanoDrop2000c UV–Vis Spectrophotometer and 0.8%

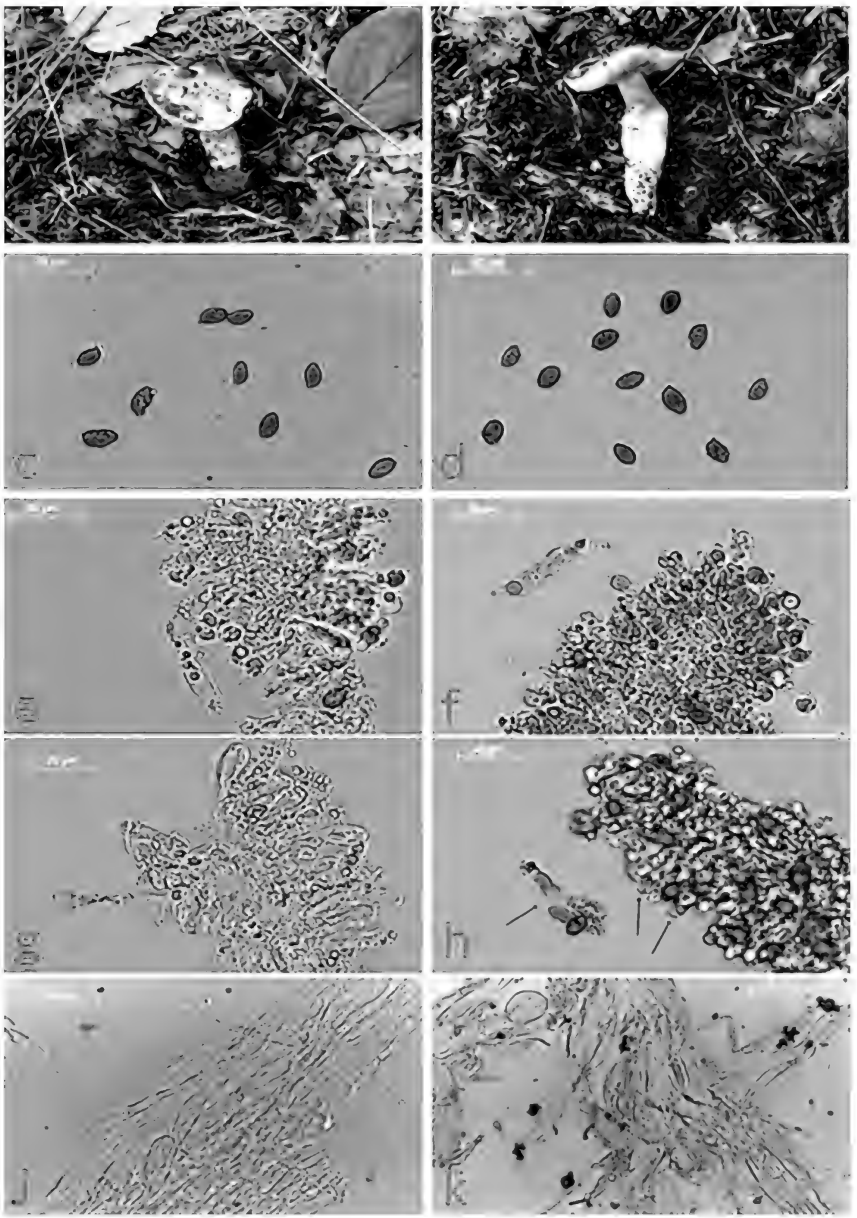

FIG. 1. *Cortinarius barbatus* (VANF Acar1076): a, b. Basidiocarp; c, d. Basidiospores; e, f. Basidia; g, h. Marginal cells; i, k. Pileipellis. (d, f, h, k in Congo Red).

agarose gel electrophoresis. DNA was amplified in 25 µl volume mixtures containing genomic DNA (10 ng/µl), 10× PCR Buffer, $MgCl_2$ (25 mM), dNTP mixture (10 mM), selected primer pair (10 µM), Taq polymerase (5u/µl) and sterile water. The ITS (ITS1-5.8S-ITS2) region was amplified using primer pairs N-nc18S10 5′AGGAGAAGTCGTAACAAG3′ and C26A 5′GTTTCTTTTCCTCCGCT3′ (Wen & Zimmer 1996). The amplicons were run in a 1% agarose gel and visualized by staining with Gelred dye. Positive reactions were sequenced with forward and reverse PCR primers in an ABI 3730XL automated sequencer, and the resulting sequences were assembled and edited using Alibee Multiple Alignment 3.0 software from the GeneBee website (www.genebee.msu.su/genebee.html). Ambiguous sites were checked manually and corrected through strand comparison. The newly generated ITS sequences were deposited in GenBank.

Phylogenetic results

The amplified ITS region was approximately 650 bp long and encompassed the complete ITS1, 5.8S and ITS2 subregions. Basic Local Alignment Search Tool (BLAST) (Altschul & al. 1997) analysis was performed using the National Center for Biotechnology Information (NCBI) database. Identity values of our three specimens were: *C. barbatus* 99.14%; *C. saturninus* 99.78%; and *C. osmophorus* 100%.

Taxonomy

Cortinarius barbatus (Batsch) Melot, Doc. Mycol. 20(77): 94 (1989) FIG. 1

PILEUS 20–50 mm, hemispherical when young, later convex to plane, sticky, glabrous, white to ivory with a white margin. LAMELLAE cream colored when young, later greyish cream brown and brown colored when mature. STIPE 35–70 × 5–10 mm, cylindrical to ventricose-fusiform and rooting, the aerial portion is yellowish brown over a white ground, the subterranean portion is white, longitudinally fibrillose, weakly viscid.

BASIDIOSPORES 7–9.5(–9.8) × 4–5(–5.7) µm, amygdaliform, rather weakly verrucose, pale straw-colored. BASIDIA 24–35 × 6–8.4 µm, cylindrical to clavate, guttulate, hyaline. MARGINAL CELLS 14.5–23 × 5.2–7 µm, clavate, hyaline. PILEIPELLIS hyphae ≤27 µm diam, clamp connections absent.

SPECIMEN EXAMINED: **TURKEY, HAKKÂRI, Şemdinli**, Öveç village, 37.3718°N 44.4762°E, 1484 m, under *Populus* and *Quercus* sp., 15.10.2018, I. Acar (VANF Acar1076; GenBank MN197665).

COMMENTS—*Cortinarius barbatus* is characterized by its white cap and stipe, bitter flesh, cream-greyish gills, and amygdaliform spores. According to Soop (2018), key characters of *C. barbatus* are its white cap and bitter flesh, which our material also possesses.

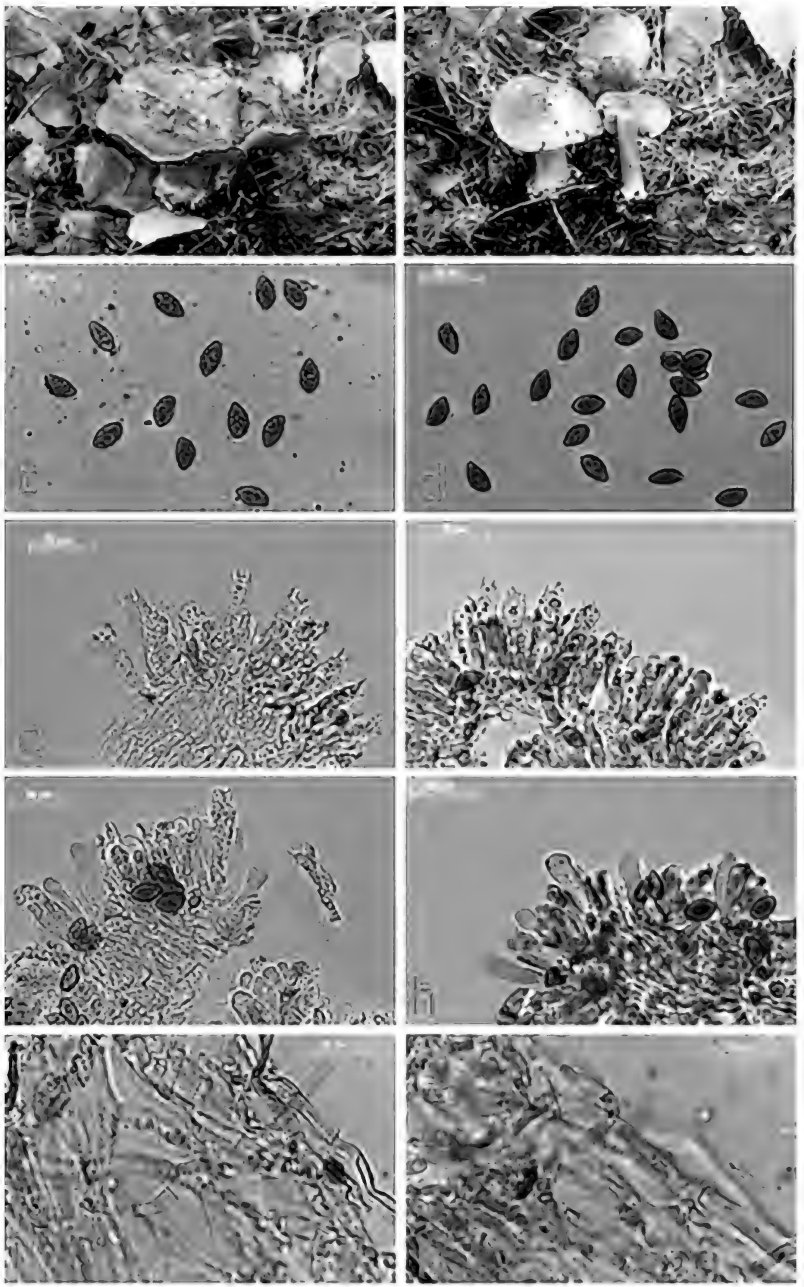

Fig. 2. *Cortinarius osmophorus* (VANF Acar1133): a, b. Basidiocarps; c, d. Basidiospores; e, f. Basidia; g, h. Marginal cells; i, k. Pileipellis. (d, f, h, k in Congo Red).

Cortinarius barbatus is morphologically similar to *C. alboamarescens* Kytöv. & al. and *C. emollitoides* Bidaud & al., but the three taxa are molecularly distinct.

Cortinarius osmophorus P.D. Orton, Trans. Brit. Mycol. Soc. 43(2): 210 (1960) Fig. 2

Pileus 50–90 mm, hemispherical to convex when young, then expanded, curved when mature, initially light yellow, whitish to cream, pale ochraceous yellow when young, ochraceous to brownish when mature, surface viscous, without veil remnants. Odour strong, sweetish (like orange blossoms). Lamellae greyish white, then brown colored. Stipe 40–70 × 7–17 mm, whitish, yellowish brown, longitudinally brown fibrillose due to cortina, the base abruptly marginate and covered with a whitish veil at the margin.

Basidiospores 9–11(–13) × (4.6–)5-6(–7) µm, amygdaliform to citriform or ellipsoid, coarsely verrucose. Basidia 26–40 × 6.5–9.3 µm, hyaline, cylindrical to clavate. Marginal cells 18–30 × 5–10 µm, mainly clavate, sometimes cylindrical or lageniform. Pileipellis hyphae ≤8 µm diam, clamp connections present.

Specimen examined: **TURKEY, Bingöl, Genç**, Tarlabaşı village, 38.6981°N 40.490°E, 1165 m, under *Populus* and *Quercus* sp., 03.12.2018, I. Acar (VANF Acar1113; GenBank MN197666).

Comments—Phillips (2006) previously reported *Cortinarius osmophorus* from beech woods on chalk, while the collection from Bingöl associated with *Populus* and *Quercus* spp.

Cortinarius osmophorus, which is similar to *C. aquilanus* T.S. Jeppesen & Frøslev, *C. cruentipellis* Kytöv. & al., *C. caesiocortinatus* Jul. Schäff., and *C. talus* Fr., characteristically has a strong orange blossom odor resembling that of *Hebeloma sacchariolens*.

Cortinarius saturninus (Fr.) Fr., Epicr. Syst. Mycol.: 306 (1838) Fig. 3

Pileus 30–100 mm, obtusely conic, hemispherical or campanulate when young, with or without low broad umbo, surface smooth, strongly hygrophanous, pale ochraceous, brown to reddish brown, chestnut-brown with a purple to violet tinge, centre sometimes red-brown, silvery shining, margin covered with white fragments and fibrils. Lamellae rather broadly adnate, cinnamon to purple-brown, then ocher brown, often with a violet tinge, edge paler. Stipe 30–80 × 7–18 mm, cylindrical, often slender, swollen towards base to subbulbous, silvery whitish to greyish violet, apex violet, covered with longitudinal white fibrils.

Basidiospores 7.5–11.7 × 4–6 µm, oblong, elliptic, amygdaliform, moderately to strongly verrucose. Basidia 25–37 × 5–10 µm, hyaline, cylindrical

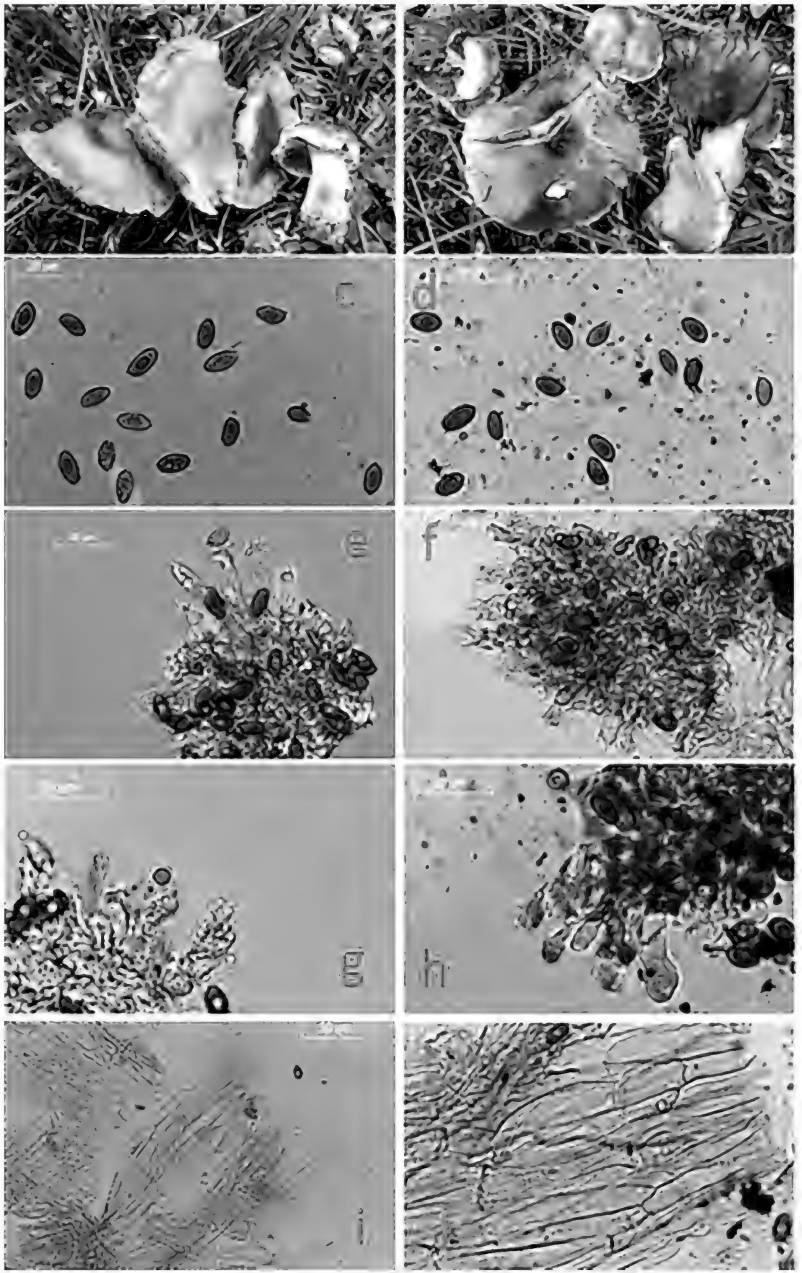

Fig. 3. *Cortinarius saturninus* (VANF Acar1055): a, b. Basidiocarps; c, d. Basidiospores; e, f. Basidia; g, h. Marginal cells; i-j. Pileipellis (d, f, h, j in Congo Red).

to clavate, 4 spored. Marginal cells 17–25 × 4–7.5 µm, cylindrical to clavate. Pileipellis hyphae ≤18 µm diam, clamp connections absent.

Specimen examined: **TURKEY, Bitlis, Kuzgunkuran** gateway, 38.3644°N 42.7561°E, 1938 m, roadside, under *Salix* sp. trees, 15.05.2018, I. Acar (VANF Acar1055; GenBank MN197667).

Comments—*Cortinarius saturninus* is characterized by persistent veil remnants on the stipe and strongly verrucose spores. Lange (1938) who reported *C. saturninus* in Flora Agaricina, describes material that differs slightly [mostly ellipsoid spores] from our material due to the different ecological conditions. Our material is highly compatible with the descriptions by Phillips (2006) and Soop (2018).

Cortinarius saturninus, which is highly variable in the field, may easily be confused with *C. confirmatus* Rob. Henry, *C. cyprinus* Bidaud & al., and *C. imbutus* Fr., which can occur in similar habitats.

Discussion

Cortinarius barbatus belongs to *C.* sect. *Vibratiles* (in *C.* subg. *Myxacium*) and characterized by white pileus and stipe, bitter flesh, and amygdaloid spores (Soop 2018; Soop & al. 2019). *Cortinarius* sect. *Vibratiles* is characterized by medium-small size basidiomes, a viscous pileus and stipe, and bitter context. Phylogenetically *C. barbatus* appears closely related to *C. alboamarescens* and *C. emollitoides*. Determining *C. barbatus* and *C. alboamarescens* to species can be difficult because of the morphological similarities. ITS sequence differences separated *C. barbatus* (our sample) from *C. alboamarescens* with fewer than 10 substitutions and indel positions. *Cortinarius alboamarescens* is characterized by very small almost subglobose spores and is the only known white species of the section that occurs in coniferous forests (Ariyawansa & al. 2015). *Cortinarius emollitoides* is distinguished from *C. barbatus* by its viscid yellow to yellow-brown pileus and less bitter taste.

Phylogenies by Garnica & al. (2005) and Frøslev & al. (2007) place *C. osmophorus* in *C.* sect. *Calochroi* (of *C.* subg. *Phlegmacium*). Species in this section are characterized by basidiomes with an abruptly marginate stipe base, well-developed gelatinous pileus, and KOH-reactive pigments (Garnica & al. 2009). *Cortinarius osmophorus* is characterized by the sticky, pale yellowto brownish pileus, abruptly marginate stipe, ornamented spores, and strong odour. The species grows mainly in *Fagus* forests in the Southern hemisphere (Phillips 2006, Frøslev & al. 2006, Soop 2018). Macroscopically, *C. osmophorus* resembles *C. aquilanus*. However, *C. aquilanus,* which grows

under *Fagus sylvatica,* is distinguished from *C. osmophorus* by its fairly sparse veil remnants and yellowish spots on the stipe (Frøslev & Jeppesen 2008). Additionally, *C. caesiocortinatus* and *C. cruentipellis* are separated from *C. osmophorus* by their purple-colored lamellae (Soop 2018).

Cortinarius saturninus, which belongs to *C.* sect. *Saturnini* (Liimatainen & al. 2017), differs from related species by its persistent veil remnants on the stipe and strongly verrucose spores. The species may be confused with *C. imbutus, C. cyprinus,* and *C. confirmatus,* also representatives of *Cortinarius* subg. *Telamonia,* in the field because they can occur in similar habitats. Lilac-greyish lamellae and abundant veil remnants on the stipe help identify *C. imbutus.* Liimatainen & al. (2017), characterize *C. confirmatus* by by one of the following character combinations: (1) absence of veil remnants on the stipe and not fruiting in dense clusters, (2) abundant veil remnants on the stipe and densely fruiting under *Populus alba,* or (3) a reddish tinted pileus and densely fruiting under *Betula pendula*. Phylogenetically, *C. saturninus* (our sample) and its sister species *C. cyprinus* differ by 3 substitutions and 2 indels.

Both morphological and molecular analyses support the identification of the newly recorded *Cortinarius* species in the current study. The addition of these three additional species increases the total of reported *Cortinarius* species in Turkey to 119.

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I would like to thank to Research Assistant Aysenur Kalmer for useful comments regarding the molecular section. I also thank Editor-in Chief Norvell and the pre-submission reviewers Dr Bálint Dima (Eötvös Loránd University, Budapest, Hungary) and Dr Abdullah Kaya (Karamanoğlu Mehmetbey University, Turkey) for their valuable suggestions.

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Notes on lichenized fungi of chroodiscoid *Thelotremataceae* from China

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Abstract—Chinese collections representing eleven species in four genera of lichenized chroodiscoid *Thelotremataceae* are reviewed taxonomically. Four species—*Astrochapsa platycarpella*, *Chapsa patens*, *C. diploschistoides*, *C. pulchra*—are reported as new records for China. Each new record is described, illustrated, and discussed in detail. Descriptions and remarks are also provided for the other seven species previously reported from China—*Astrochapsa mirabilis*, *Chapsa indica*, *C. leprocarpa*, *Chroodiscus argillaceus*, *Reimnitzia santensis*, *Rhabdodiscus asiaticus*, and *Xalocoa ocellata*.

Key words —*Graphidales*, *Ostropomycetidae*, *Lecanoromycetes*

Introduction

The most recent taxonomic concept of lichen forming *Lecanoromycetes* accepts the resurrected family *Thelotremataceae* Stizenb. in *Graphidales* (*Ostropomycetidae;* Kraichak & al. 2018, Lücking 2019). In *Thelotremataceae* ascomata are true apothecia with hemiangiocarpous development, where crater-like apothecia form their double margin from the cupulate proper exciple and an outer thallus layer (= thalline margin; Matsumoto 2000, Frisch 2006). The characteristics of proper exciple, thalline margin, columella structures, carbonization, and other features determine five types that describe the considerable differences in apothecial morphology: *Chroodiscus*-type, *Fibrillitheces*-type, *Myriotrema*-type, *Ocellularia*-type, and *Thelotrema*-type (Frisch 2006). The *Chroodiscus*-type apothecia, referred to as chroodiscoid by Hale (1981), are rounded, reniform, angular or star-shaped, and usually large

with a distinctly exposed disc surrounded by a jagged, fissured, or lobed (rarely entire) margin that is erect to recurved or exfoliating (Frisch 2006, Mangold 2008). The chroodiscoid genera in *Thelotremataceae* are: *Acanthotrema*, *Astrochapsa* Parnmen & al., *Asteristion*, *Chapsa* A. Massal., *Cruentotrema*, *Chroodiscus* (Müll. Arg.) Müll. Arg., *Enigmotrema*, *Gyrotrema*, *Gintarasia*, *Myriochapsa*, *Nitidochapsa*, *Pseudochapsa*, *Reimnitzia* Kalb, *Rhabdodiscus* Vain., and *Xalocoa* Kraichak & al.

The literature has reported seven species—*Astrochapsa mirabilis*, *Chapsa indica*, *C. leprocarpa*, *Chroodiscus argillaceus*, *Reimnitzia santensis*, *Rhabdodiscus asiaticus,* and *Xalocoa ocellata*—from China (see below). During our recent research and compilation of Flora Lichenum Sinicorum, additional small genera (e.g., *Carbacarthographis*, *Myriotrema*, *Schizotrema*) have been described from China. (Jia & al. 2017, Liu & al. 2018, Xu & al. 2016, Jia & Lücking 2020). We report here on specimens collected from Fujian and Hainan provinces that represent four *Astrochapsa* and *Chapsa* species new to China: *A. platycarpella*, *C. patens*, *C. diploschistoides*, and *C. pulchra*.

Materials & methods

The specimens are deposited in the Fungarium of College of Life Sciences, Liaocheng University, China (LCUF). An Olympus SZX16 dissecting microscope and a Olympus BX53 compound microscope were used for morphological studies. Measurements were taken from mature cross sections of fruit bodies mounted in water. Ascospore amyloidity was tested using Lugol's solution. Spot tests were performed on the thallus surface with K (10% KOH aqueous solution), C (saturated aqueous NaOCl solution), and PD (saturated p-phenylenediamine solution in 95% ethyl alcohol). The lichen substances were detected and identified by thin-layer chromatography, using solvent C (Culberson & Kristinsson 1970, Culberson 1972, White & James 1985, Jia & Wei 2016).

Taxonomy (Four new records for China)

Astrochapsa platycarpella (Vain.) Parnmen, Lücking & Lumbsch, PLoS One 7(12): e51392, 9 (2012) Fig. 1a–c

Thallus crustose, corticolous, brown-olive, smooth or uneven to warty. Apothecia scattered to aggregate in groups, level with the thallus, angular-rounded, 0.5–1.5 mm diam. Margin thin, lobulate to recurved, sometimes fused with a white pruinose inner surface. Disc exposed, pale brown to blackish, with distinct and coarse bluish white pruina. Proper exciple fused, brown at the base; periphysoids ≤35 µm long, free. Hymenium clear, 50–100 µm high; paraphyses unbranched, straight, 1.5–2 µm wide, tips slightly

thickened, with brownish granules. Asci clavate, 50–90 × 7–9 µm, 8-spored. Ascospores hyaline, transversely septate, 4–6-loculate, 15–18 × 4–5 µm, thin walled to slightly thickened at the edges of the lumina, with distal oblong ends tapering, I–.

Chemistry: Thallus K–, C–, PD–; no lichen substances detected by TLC.

Specimens examined: **CHINA. Hainan Province, Ledong County**, Mt. Jianfengling, Yulingu. alt. 630 m, on bark, 10-XII-2019, M. Li HN19362, HN19365, HN19368, HN19377, HN19382 (LCUF).

Ecology & distribution: In China on bark in an evergreen tropical rain forest. Distributed in Africa, South America, and India (Frisch 2006; Joshi et al. 2018). New to China.

Remarks: *Astrochapsa platycarpella* is very close to *A. astroidea* (Berk. & Broome) Parnmen & al. but differs in having aggregated apothecia, a bluish white pruinose disc and white pruinose marginal lobules with solitary to fused apothecia, grayish pruinose discs, and rarely layered lobules. Mangold (2008) synonymised *Chapsa platycarpella* under *C. astroidea*, but Parnmen & al. (2012) transferred them both to *Astrochapsa* as separate species. *Chapsa alborosella* (Nyl.) Frisch is also similar but has an ecorticate thallus, dispersed apothecia, and 5–9-septate ascospores.

Chapsa diploschistoides (Zahlbr.) Frisch, Biblioth. Lichenol. 92: 99 (2006) Fig. 1D–F

Thallus crustose, corticolous, pale to dark olive-grey or brownish, slightly uneven to warty. Apothecia dispersed, level with the thallus, rounded to angular, 0.5–1 mm diam. Margin thick, raised, deeply fissured to lobed, incurved to upright, often in two or three separate layers. Disc slightly exposed, pale brown, covered by thin white pruina. Proper exciple deeply cupulate, hyaline to pale brown at the base; periphysoids ≤20 µm long, free. Hymenium clear, 70–90 µm high; paraphyses unbranched, straight, 2–2.5 µm diam, tips indistinctly moniliform and often a slight dendroid branching, adspersed with fine brownish granules. Asci narrowly clavate, 70–85 × 8–12 µm, 8-spored. Ascospores hyaline, transversely septate, 6-locular, 18–25 × 5.5–6.5 µm, thin walled, with subacute ends, I–.

Chemistry: Thallus K–, C–, PD–; unknown lichen substances detected by TLC.

Specimen examined: **CHINA. Hainan Province, Changjiang County**, Mt. Bawangling, Yajia. alt. 650 m, on bark, 08-VII-2019, Y.H. Ju HN19163 (LCUF).

Ecology & distribution: In southern China on bark in a tropical forest near a valley waterfall. Also known from South Africa (Frisch 2006). New to China.

Remarks: *Chapsa diploschistoides* is similar to *C. alborosella* but differs by its thicker, fissured to fissured-areolate thallus with distinct warts, a more compact and glossier thallus surface, and apothecia with an incurved layered margin having a compact (not white-felty) inner surface. Our Chinese material has smaller ascospores than that from south Africa noted by Frisch (2006; 20–33 × 6–7 μm).

Chapsa patens (Nyl.) Frisch, Biblioth. Lichenol. 92: 111 (2006) Fig. 1G–I

Thallus crustose, corticolous, greenish grey, often somewhat brownish, slightly uneven to warty. Apothecia dispersed, level with the thallus, rounded to slightly angular, 1–2.5 mm diam. Margin thick, strongly raised, deeply fissured to lobed, incurved to upright but usually not strongly recurved in the apical parts. Disc exposed, pale brown, covered by thick and coarse white pruina. Proper exciple deeply cupulate, hyaline to pale brown at the base; periphysoids ≤50 μm long, free. Hymenium clear, 130–200 μm high; paraphyses unbranched, straight, 2–2.5 μm diam, tips strongly moniliform and intensely adspersed with fine brownish granules. Asci clavate, 100–180 × 25–40 μm, 1-spored. Ascospores hyaline (slightly brownish in age), densely muriform, 80–120 × 20–30 μm, thin walled, with rounded ends, with a narrow halo, I–.

Chemistry: Thallus K–, C–, PD–; no lichen substances detected by TLC.

Specimens examined: **China. Fujian Province: Qianzhou City**, Mt. Jiuxian, Huizhaochi. alt. 1540 m, on bark, 25-VII-2019, F.Y. Liu FJ19127-1, FJ19128-1, FJ19131, FJ19148-2 (LCUF).

Ecology & distribution: In southern China on bark in a subtropical forest. Widely distributed in Africa, Japan, Sri Lanka, and India (Matsumoto 2000, Frisch 2006, Joshi & al. 2012). New to China.

Remarks: *Chapsa patens* is similar to *C. leprocarpa*, which differs by having a slightly lower hymenium and smaller ascospores (65–85 × 15–23 μm; see Chinese material of *C. leprocarpa*, below). Hale (1981) and Matsumoto (2000) described *C. patens* as having stictic acid, while Frisch (2006) noted that the lectotype definitely lacks stictic acid. The ascospores of *C. patens* in our Chinese collection are slightly smaller than those from Africa (90-158 × 22-35 μm; Frisch 2006) and India (80–125 × 20–35 μm; Joshi & al. 2012).

Chapsa pulchra (Müll. Arg.) Mangold,
Flora of Australia 57(Lichens 5): 654 (2009) Fig. 1J–L

Thallus crustose, corticolous, thin, pale gray to pale grayish-green, smooth to usually rough. Apothecia scattered, level with the thallus,

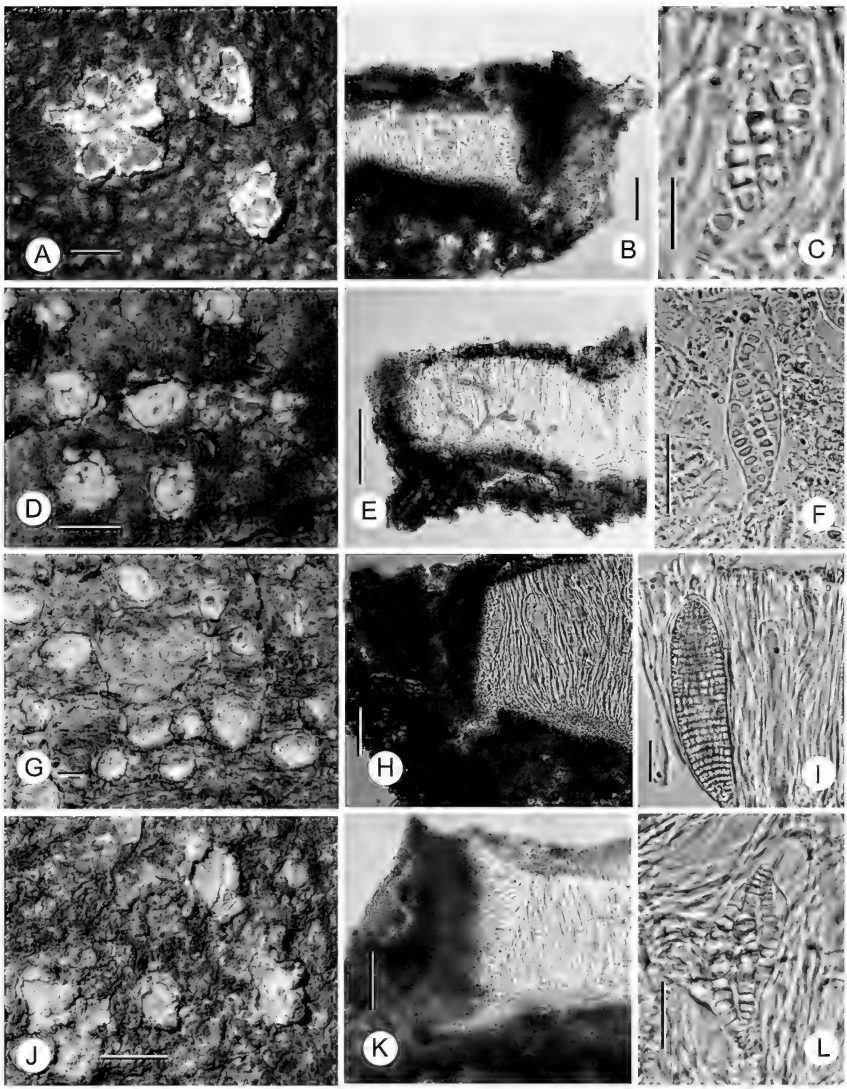

Fig.1 ***Astrochapsa platycarpella*** (LCUF – Li HN19365): A: habit; B: apothecial section; C: ascus containing ascospores. ***Chapsa diploschistoides*** (LCUF – Ju HN19163): D: habit; E: apothecial section; F: ascus containing ascospores. ***Chapsa patens*** (LCUF – Liu FJ19131): D: habit; E: apothecial section; F: ascus containing one muriform ascospore. ***Chapsa pulchra*** (LCUF – Li HN19422): G: habit; H: apothecial section; I: ascus containing ascospores. Scale bars: A, D, G, J = 1 mm; B, E, H, K = 50 μm; C, F, I, L = 20 μm.

roundish to irregular, 1–2 mm diam. Margin thick, lobed to eroded, rarely slightly layered, pruinose, becoming erect to recurved. Disc partly to entirely visible from surface, pale flesh-colored to grayish, with distinct pruina. Proper exciple fused, brown at the base; periphysoids ≤30 µm long, free. Hymenium clear, 100–130 µm high; paraphyses unbranched, straight, 1.5–2 µm diam, tips slightly thickened. Asci clavate, 80–100 × 10–18 µm, 6- or 8-spored. Ascospores hyaline, transversely septate, 12–20-loculate, 30–65 × 5–7 µm, thin walled to slightly thickened at the edges of the lumina, with distal oblong ends tapering, I–.

Chemistry: Thallus K–, C–, PD–; no lichen substances detected by TLC.

Specimen examined: **CHINA. Hainan Province: Ledong County**, Mt. Jianfengling, Yulingu. alt. 630 m, on bark, 10-XII-2019, M. Li HN19422 (LCUF).

Ecology & distribution: In southern China on bark in an evergreen tropical rain forest. Previously known only from Australia (Mangold 2008). New to China.

Remarks: The species is very similar to *Chapsa indica*, which produces much larger ascospores with more septa (see below). Another similar species is *Chapsa alborosella* (Nyl.) Frisch, which is distinguished by smaller ascospores with fewer septa (5–9-septate, 17–22 × 3–6 µm; Mangold 2008).

Seven other thelotrematoid species known from China

Astrochapsa mirabilis (Zahlbr.) Lücking & S. Joshi, Lichenologist 50(6): 633 (2018)

The species is characterized by a corticate olive-green to greyish green thallus, angular apothecia with recurved margins, greyish disc covered with thick white pruina, carbonized exciple, inspersed hymenium, 8-spored asci, brown muriform 8–10/3–4-loculate ascospores measuring 40–50 × 11–15 µm, and stictic acid.

Reported from Fujian Province of China (Zahlbruckner 1930, Jia & Lücking 2017) and India (Joshi et al. 2018). Pantropical Asia.

Chapsa indica A. Massal., Atti Reale Ist. Venet Sci. Lett. Arti., Sér. 3, 5: 257 (1860).

The species is characterized by the small angular or shortly elongated apothecia with a usually densely white-felty disc, *Chapsa*-type paraphyses and periphysoids, large hyaline transversely septate 18–35-loculate ascospores (65–100 × 5.5–8 µm), and the absence of lichen compounds. Its apothecia, ascospore type, and lichen compounds are similar to *C. pulchra*, which differs by its smaller ascospores (see above).

Reported from Hainan Province of China (Xu & al. 2016). Distributed mainly in Africa (Sierra Leone, Kenya, Mozambique), Asia (India, Sri Lanka, Borneo, Malaya, Andaman Islands), and Australia (Patwardhan & Nagarkar 1980; Nagarkar & al. 1986, 1988; Frisch 2006; Mangold 2008). Pantropical, extending to subtropical regions.

Chapsa leprocarpa (Nyl.) Frisch, Biblioth. Lichenol. 92: 108 (2006).

The species is characterized by the chroodiscoid apothecia with lobed and recurved margins, white heavily pruinose disc, one solitary muriform ascospore per ascus (60–85 × 15–23 µm), and absence of lichen compounds. It is similar to *Chapsa patens*, which is distinguished by larger ascospores (see above).

Reported from Guangxi Province of China (Xu & al. 2016). Distributed mainly in Africa, Sri Lanka, India, Borneo, USA, Brazil, and Australia (Hale 1981, Sipman 1993, Frisch 2006, Mangold 2008). Pantropical, extending to subtropical regions in both hemispheres.

Chroodiscus argillaceus (Müll. Arg.) Lücking & Papong, Bryologist 112(1): 154 (2009)

The species is characterized by a grayish green thallus, immersed to erumpent apothecia with recurved margins, flat opened dark grey discs, 8-spored asci, colorless ellipsoid 3-septate ascospores (6–10 × 2.5–3 µm), and absence of lichen substances. It is similar to *Chroodiscus khaolungensis* Papong & Lücking, which has larger ascospores (18–24 µm; Papong & al. 2009, Wang & Wei 2018).

Reported from Hainan Province of China (Wang & Wei 2018). Distributed mainly in Southeast Asia (Papong & al. 2009).

Reimnitzia santensis (Tuck.) Kalb, Mycotaxon 79: 325 (2001)

The species is characterized by a thallus with large columns of calcium oxalate crystals and abundant isidia, chroodiscoid ascomata, brown submuriform ascospores (15–25 × 8–12 µm), pycnidia with bacilliform conidia, and absence of lichen substances.

Reported from Zhejiang Province of China (Dou & al. 2019). Pantropical (Kalb 2001, Frisch 2006, Mangold 2008).

Rhabdodiscus asiaticus (Vain.) Rivas Plata, Lücking & Lumbsch, Taxon 61(6): 1175 (2012)

= *Thelotrema formosanum* Zahlbr., Repert. Spec. Nov. Regni Veg. 33: 24 (1933)

The species is characterized by its greyish to olive thallus, semi-emergent apothecia, thick brownish to distinctly carbonized proper exciple, well-

developed carbonized columella, 8-spored asci, transversely septate to indistinctly submuriform hyaline (occasionally pale brownish) ascospores (10–40 × 7–12 μm), and psoromic acid.

Rhabdodiscus asiaticus resembles *R. fissus* (Müll. Arg.) Vain., which differs in having smaller brown submuriform ascospores. Aptroot (2004) listed *Thelotrema formosanum* as a synonym of *Ocellularia asiatica* [≡ *R. asiaticus*], noting that its Taiwanese type had been erroneously cited as "Asahina no. 330" [correctly TNS Asahina F230], and that psoromic acid (TLC; PD+ deep yellow) was detected from the thallus, the ascospores are I+ violet, and the columella is conspicuous, simple, and visible from the outside.

Reported from China's Taiwan Province (Zahlbruckner 1933, as *Thelotrema formosanum;* Wang-Yang & Lai 1973, as *T. formosanum*; Aptroot 2004). Distributed mainly in Vietnam and India (Vainio 1907, Joshi et al. 2018). Pantropical Asia.

Xalocoa ocellata (Fr.) Kraichak, Lücking & Lumbsch, Austral. Syst. Bot. 26(6): 472 (2013)

The species is characterized by the greyish to pale yellow thallus, sessile discoid lecanoroid apothecia (1–2 mm diam.), grayish pruinose disc, thick non-carbonized proper exciple, 8-spored asci, ellipsoid muriform 3–5/0–2-septate brown ascospores (15–30 × 7.5–15 μm), and norstictic acid.

Xalocoa ocellata resembles *Diploschistes cinereocaesius* (Sw.) Vain., which differs by its larger (≤3.6 mm diam.) apothecia, and lecanoric acid with traces of diploschistesic acids.

Reported from Yunnan and Sichuan Provinces (Zahlbruckner 1930, as *Diploschistes ocellatus*). This species is cosmopolitan (Kraichak & al. 2013).

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Five new foliicolous micromycete records from Turkey

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Abstract—Among microfungi collected on foliar spots of vascular plants in Yedigöller National Park, Bolu Province, Turkey, five species represent new records for Turkey: *Ascochyta daturae, A. euonymi*, *Mycosphaerella laureolae*, *Phyllosticta datiscae,* and *Rhabdospora visci.* Detailed descriptions and photographs of these species are provided.

Key words—*Ascomycota*, biodiversity, new host, SEM, taxonomy

Introduction

Microfungi can cause various diseases through leaf infection. *Ascochyta* Lib., *Mycosphaerella* Johanson, *Phyllosticta* Pers., and *Rhabdospora* (Durieu & Mont.) Sacc. are among the genera that include species causing foliar spots. Some of these foliar-pathogenic fungi show host specificity, while others can be found on several hosts: e.g., *Rhabdospora visci* infects only *Viscum album*, while *Ascochyta daturae* is observed on more than one species in *Solanaceae*.

Foliar pathogens causing needle or leaf-bound diseases can cause growth reduction as a result of a decrease in photosynthetic capacity at high levels of infection (Van der Pas 1981, Manter & al. 2003, Hanso & Drenkhan 2012).

Tree mortality can be seen only in serious cases. By weakening the tree, leaf diseases can contribute to higher sensitivity to biotic and abiotic stresses (Bednářová & al. 2013, Kowalski 2013). Based upon trophic interactions with the host, different pathogen species can be distinguished; for instance, while necrotrophic fungi live on dead cells, biotrophic fungi directly derive carbon and nutrients from living cells (Deacon 1997).

The Yedigöller National Park, located in the northern part of Bolu Province in the Western Black Sea Region in Turkey, includes seven lakes and many streams. The park is situated in square A3 of the Davis (1965–85) grid square system. The climate of the province is oceanic, and it rains during all seasons.

The research area comprises primarily mixed forest vegetation. At lower elevations the forest is dominated by *Fagus orientalis*, *Carpinus orientalis*, *Quercus* spp., *Sambucus nigra*, *Sorbus aucuparia*, *S. torminalis*, *Corylus colurna*, *Acer campestre*, *A. platanoides*, *Cornus mas*, *Populus tremula*, and *Alnus glutinosa*. Regions at upper elevations are covered with *Gymnospermae* such as *Abies nordmanniana* subsp. *equi-trojani*, *Pinus nigra*, *P. sylvestris*, and *Taxus baccata*. The understory contains shrubs such as *Daphne pontica*, *Rhododendron ponticum*, and *Juniperus oxycedrus*. The research area is also rich in marshy habitats, and there are aquatic plants in the lake (e.g., *Potamageton* sp., *Lemna* sp.) and marsh plants surround the edge of the lake (*Typha* sp., *Carex* spp., *Lythrum* sp.).

Materials & methods

Plant specimens infected with microfungi were collected in the Yedigöller National Park, Bolu Province, Turkey. Host specimens were prepared following conventional herbarium techniques. Host plants were identified using the Flora of Turkey and East Aegean Islands (Davis 1965–85). Thin sections prepared from infected host tissue were examined under a Leica DM E light microscope and measured from mounts in tap water. Twenty microscopic structures were measured for each sample. Infected host surfaces were photographed using a Leica EZ4D stereo microscope. Species were identified using relevant literature (*Ascochyta*: Vanev & al. 1997, Mel'nik 2000, Połeć & Ruszkiewicz-Michalska 2011; *Mycosphaerella*: Ciferri 1956; *Phyllosticta*: Sydow 1899, Cejp 1965; *Rhabdospora*: Winter 1883 [as *Septoria*], Saccardo 1884 [as *Septoria*], Diedicke 1914). All examined specimens were deposited in the Mycological Collection of the Department of Landscape Architects, Faculty of Agriculture, Kırşehir Ahi Evran University, Kırşehir, Turkey (AEUT).

For scanning electron microscopy (SEM), infected leaves were mounted on stubs with double-sided tapes. They were coated with gold in Polaron SC 502 Sputter Coater and examined with Jeol JSM 6060 SEM at 5–10 kV in the Faculty of Science, Gazi University, Ankara, Turkey.

Taxonomy

During our study on microfungi on vascular plants in Yedigöller National Park in Turkey we collected several microfungal species that cause foliar

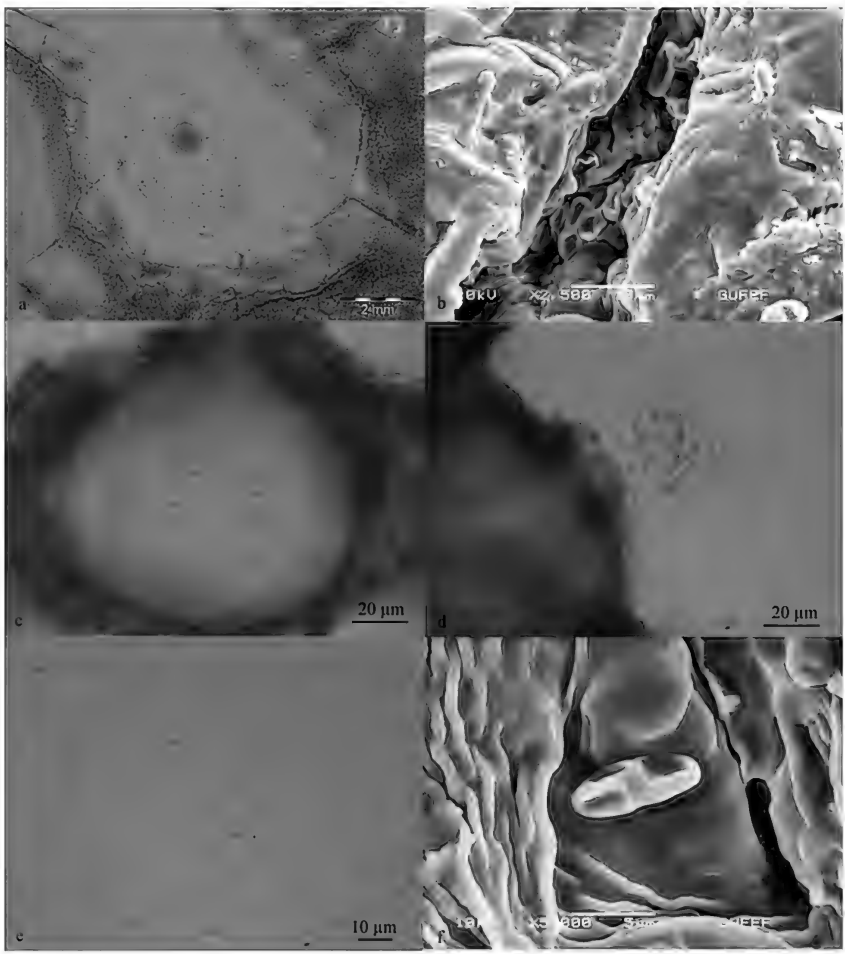

Fig. 1. *Ascochyta daturae* (AEUT GD1376). A. leaf spot (detail) showing pycnidia; B. pycnidia on leaf (SEM); C. pycnidium, vertical section; D, E. conidia; F. conidium (SEM).

spots. A check of the current literature revealed that among the microfungal species causing foliar spots determined in this study, *Ascochyta daturae*, *Ascochyta euonymi*, *Mycosphaerella laureolae*, *Phyllosticta datiscae*, and *Rhabdospora visci* represent new records for Turkey. The list of microfungi with their descriptions, host plants, habitats, localities, collection dates, and voucher numbers follow the classification provided by Index Fungorum (2020) with slight modifications.

Ascochyta daturae Sacc., Michelia 1(2): 163 (1878) FIG. 1

SPOTS visible on both sides of leaves, generally circular or angular, 5–15 mm diam., sometimes elongated 23–45 × 12–15 mm, pale brown, margin of spots dark brown. CONIDIOMATA pycnidial, epiphyllous, aggregated or scattered, unilocular, globose, globose-depressed, semi-immersed, 100–190 × 85–140 µm, light brown; ostiole circular or sometimes papillate, 25–30 µm diam. CONIDIA cylindrical, oblong, ellipsoid, 1-septate, rarely aseptate, straight or slightly curved, not or slightly constricted, both ends rounded, sometimes one end slightly narrowed, 6.4–11 × 2.8–4 µm, guttulate, hyaline.

SPECIMEN EXAMINED—**TURKEY, BOLU PROVINCE: Yedigöller National Park**, near the Büyük Lake, 40°56′28″N 31°44′51″E, 770 m asl, on living leaves of *Atropa belladonna* L. (*Solanaceae*), 28.06.2018, G. Doğan (AEUT GD1376).

DISTRIBUTION—Bulgaria (Vanev & al. 1997); Canada (Ginns 1986); China (Tai 1979); Poland (Mulenko & al. 2008); Venezuela (Urtiaga 1986).

NOTES: *Ascochyta* consists of facultative parasites that cause diseases of many cultivated and wild plants. A few species are known only from dead parts of their host plants (Mel'nik 2000). In Turkey, *Ascochyta* species are poorly known and not yet intensively studied. Some species of *Ascochyta* were reported by Bremer & al. (1947, 1948), Karel (1958), Göbelez (1964), Parlak & Gucin (1993), Eken (2003), and Kabaktepe & al. (2019). Bahçecioğlu & Kabaktepe (2013) listed 20 *Ascochyta* species from Turkey, on 25 plant species (in 21 genera and 16 families). Mel'nik (2000) synonymised *A. atropae* Bres. (the only species recorded on *Atropa belladonna*) with *A. daturae*, which has been recorded on living and dry leaves and other parts of members of *Solanaceae*. Microscopic features of our specimen corresponded to those given by Mel'nik (2000) and Połeć & Ruszkiewicz-Michalska (2011). We observed unicellular conidia on our specimens similar to those reported by Połeć & Ruszkiewicz-Michalska (2011).

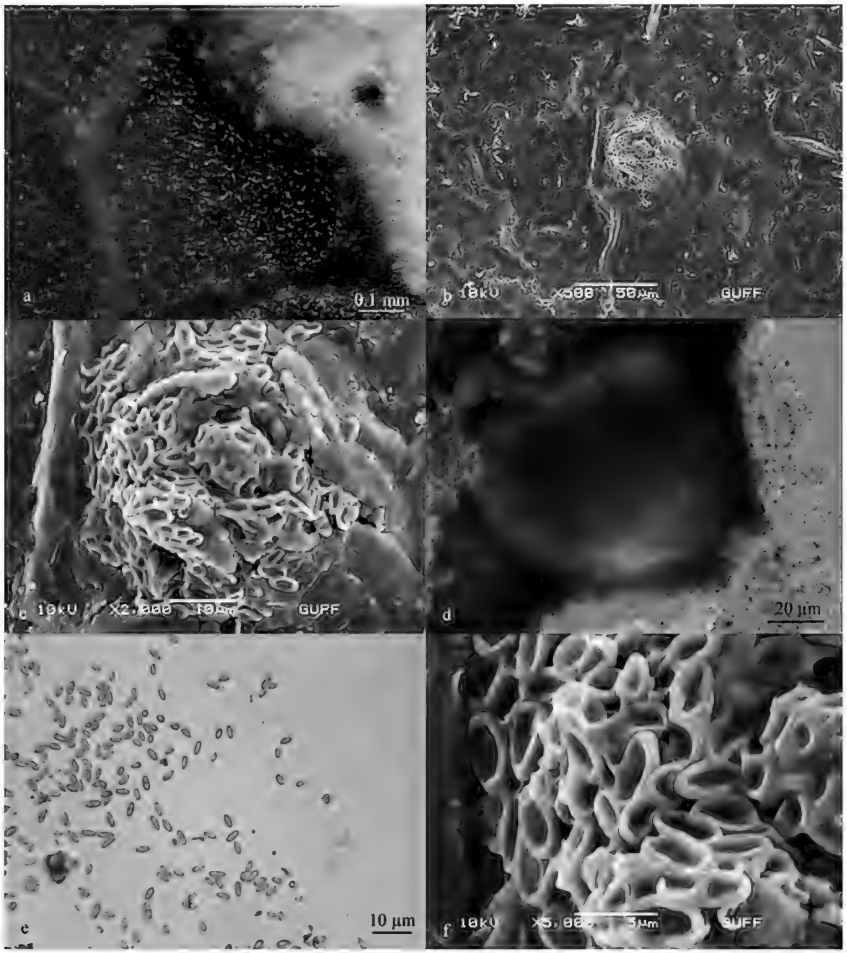

Fig. 2. *Ascochyta euonymi* (AEUT GD1980). A. leaf spots; B, C. pycnidia on leaf (SEM); D. pycnidium, vertical section; E. conidia; F. conidia (SEM).

Ascochyta euonymi Pass., Diagn. Funghi Nuovi 5: 11 (1891) Fig. 2

Spots visible on both sides of leaves, mostly circular, 10–15 mm diam., whitish, surrounded by a brown border. Conidiomata pycnidial, epiphyllous, scattered, unilocular, globose, semi-immersed, 60–115 µm diam., brown; ostiole papillate, 27–40 µm diam. Conidia cylindrical, ellipsoid, lanceolate, straight, aseptate or 1-septate, not constricted, both ends rounded, sometimes one end slightly narrowed, 3.8–6.8 × 2–3 µm, guttulate, hyaline.

Specimen examined—**TURKEY, BOLU**: Yedigöller National Park, 40°53′45″N, 31°40′06″E, 1627 m asl, on living leaves of *Euonymus verrucosus* Scop. (*Celastraceae*), 02.08.2019, G. Doğan (AEUT GD1980).

Distribution—Czechoslovakia (Farr & Rossman 2020); Georgia (Nakhutsrishvili 1986); Italy (Mel'nik 2000).

Notes: *Ascochyta euonymi, A. euonymella* (Sacc.) Allesch., *A. euonymicola* Allesch., and *A. oudemansii* Sacc. & P. Syd. are reported to infect *Euonymus* spp. (Mulenko & al. 2008, Mel'nik 2000). Our specimen is morphologically similar to *Ascochyta euonymi* as described by previous study (Mel'nik 2000), but differs in having slightly broader, shorter, 1–2-celled conidia.

Mycosphaerella laureolae (Desm.) Lindau,
Nat. Pflanzenfam. 1(1): 424 (1897) Fig. 3

Spots single or confluent, amphigenous, usually circular, irregular when confluent, 5–11 mm diam., at first blackish, becoming brown in the centre, surrrounded by a dark ring. Perithecia mostly epiphyllous, rarely hypophyllous, usually grouped in the centre of the spots, globose, 65–100 µm diam., blackish; ostiole papillate, 18–20 µm diam. Asci bitunicate, subcylindric to clavate, attenuate at the base, contracted almost stipitate, 33–50 × 8–10.7 µm. Ascospores biseriate, oblong, ovate or ellipsoid, 1-septate, straight, not constricted, both ends rounded, 12.4–15.8 × 3.6–4.7 µm, guttulate, hyaline.

Specimen examined—**TURKEY, Bolu Province: Yedigöller National Park**, Mengen road separation, 40°56′38″N 31°44′51″E, 741 m asl, on living leaves of *Daphne pontica* L. (*Thymelaeaceae*), 03.05.2019, G. Doğan (AEUT GD1792).

Distribution—Dominican Republic (Ciferri 1956); France, Germany, and Switzerland (Stevenson 1926); Morocco (Rieuf 1970, as *Sphaerella laureolae*).

Notes: *Mycosphaerella* s.lat. is one of the largest groups of ascomycetes and includes more than 3000 taxa, with species recognized as pathogens or endophytes of many plants, hyperparasites of other fungi, or saprobes (Crous 2009). Our identification of *Mycosphaerella laureolae* agrees with other descriptions of the species with respect to the morphology of perithecia, asci, and ascospores, the only observable difference being the wider dimensions of ascospores and the smaller dimensions of asci. Ciferri (1956) described ascospores measuring 10–15 × 2–3 µm and asci measuring 40–50 × 8–10 µm; and Saccardo (1882) described ascospores measuring 12–14 × 3 µm and asci measuring 44 × 8 µm (as *Sphaerella laureolae*). Here we report *Daphne pontica* as a new host for *Mycosphaerella laureolae*.

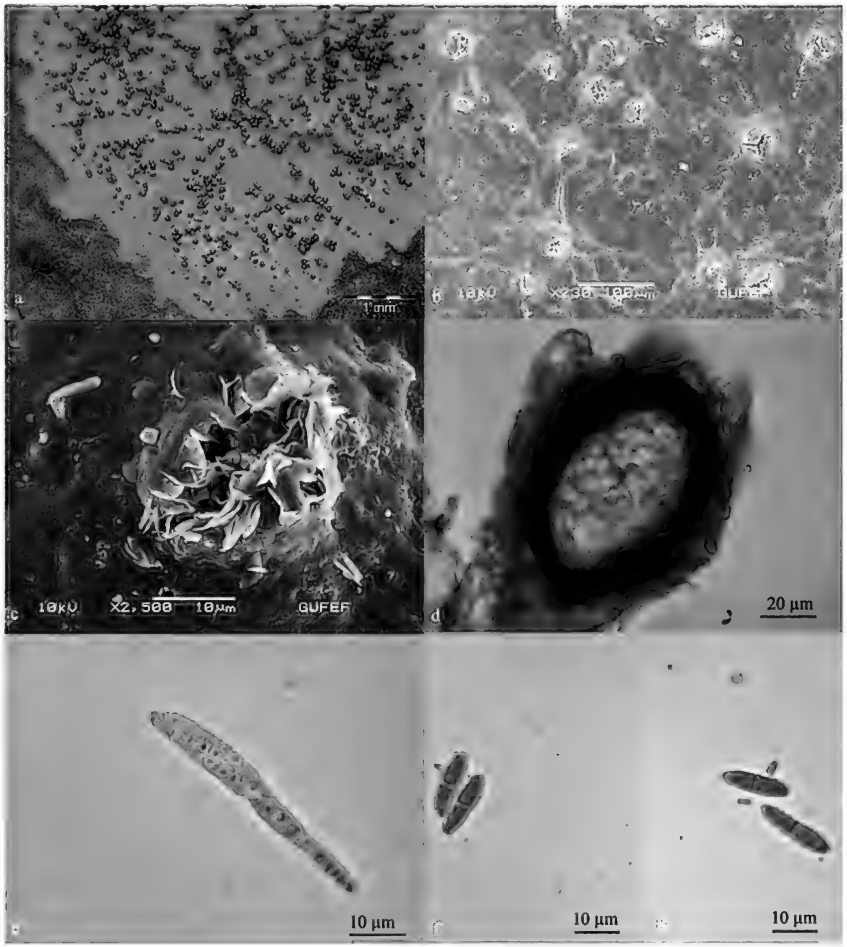

Fig. 3. *Mycosphaerella laureolae* (AEUT GD1792). A. leaf spot (detail) showing perithecia; B. perithecia on leaf (SEM); C. perithecium on leaf (SEM); D. perithecium, vertical section; E. ascus and ascospores; F, G. ascospores mounted in lactophenol cotton blue.

Phyllosticta datiscae P. Syd., Beibl. Hedwigia 38: (135) (1899) Fig. 4

Spots amphigenous, orbicular to oblong, often with concentric rings, reaching a diam. of about 1 cm, brown, margin of spots dark brown. Conidiomata pycnidial, epiphyllous, scattered, unilocular, globose-depressed, semi-immersed, 110–135 × 70–100 µm, brown; ostiole papillate. Conidia one-celled, oblong, ellipsoid, rounded at both ends, 5.5–6.9 × 2.2–2.7 µm, biguttulate, hyaline.

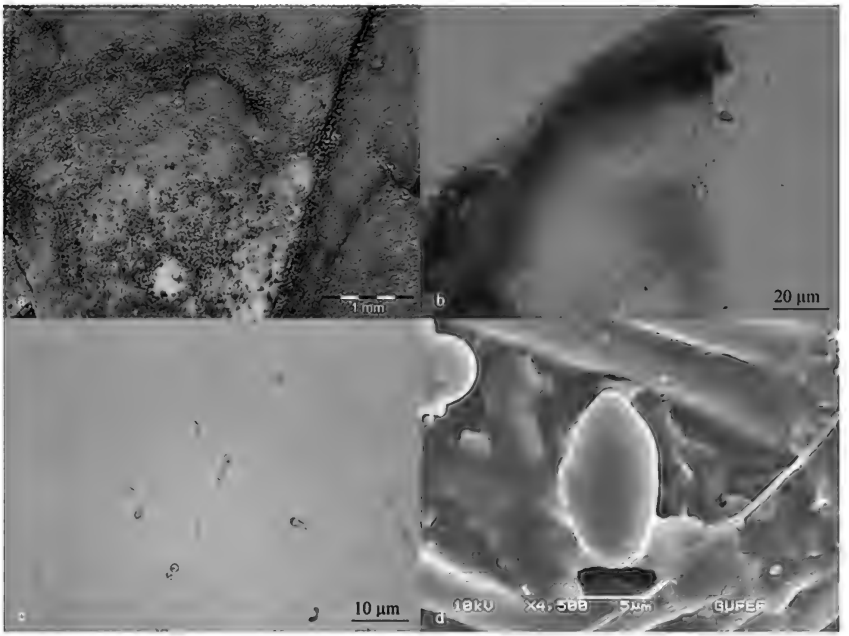

Fig. 4. *Phyllosticta datiscae* (AEUT GD2041). A. leaf spot (detail) showing pycnidia; B. pycnidium, vertical section; C. conidia; D. conidia (SEM).

Specimens examined—**TURKEY, Bolu Province: Yedigöller National Park**, 40°56′52″N 31°45′02″E, 716 m asl, on living leaves of *Datisca cannabina* L. (*Datiscaceae*), 27.06.2018, G. Doğan (AEUT GD1328); Mengen road separation, 40°56′30″N 31°44′40″E, 811 m asl, on living leaves of *Datisca cannabina*, 03.08.2019, G. Doğan (AEUT GD2041).

Distribution—Germany (Sydow 1899), Czechoslovakia (Cejp 1965).

Notes: *Phyllosticta* is an important genus of plant pathogenic fungi, causing leaf spots and various fruit diseases worldwide on a large range of hosts (Aa & Vanev 2002). Species recognition in *Phyllosticta* has historically been based on morphology, culture characters, and host association. Although there have been several taxonomic revisions and enumerations of species, there is still considerable confusion when identifying taxa (Wikee & al. 2011). *Phyllosticta datiscae* is the only species of *Phyllosticta* described on *Datisca cannabina*. The Turkish specimens agree with the description by Sydow (1899) in leaf spot, conidiomatal, and conidial morphology, except that the conidiomata are larger and the conidia smaller; in comparison with the description and illustration by Cejp (1965), the Turkish conidia were thicker and 1–2-celled.

Rhabdospora visci (Bres.) Died.,
Krypt.fl. Brandenburg 9(3): 537 (1914 ["1915"] FIG. 5

LEAF SPOTS amphigenous, raised, circular, 2–4 mm diam. or confluent and larger, pale brown, surrounded by a reddish-brown border. CONIDIOMATA pycnidial, mostly hypophyllous, scattered or in groups, unilocular, subglobose, immersed, later becoming erumpent, 175–350 µm diam., dark brown. CONIDIA filiform, straight or slightly curved, 1–3-septate, non-

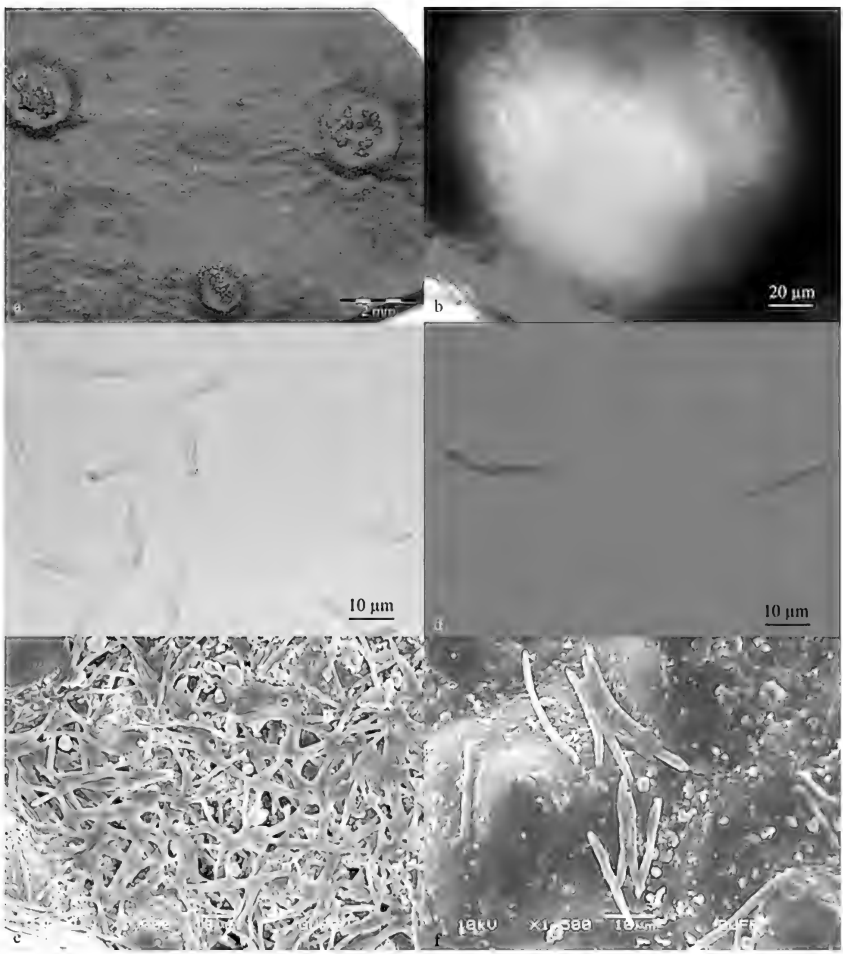

FIG. 5. *Rhabdospora visci* (AEUT GD 2014). A. leaf spot (detail) showing perithecia; B. perithecium, vertical section; C. conidia; D. ascospores mounted in lactophenol cotton blue; E, F. conidia (SEM).

constricted at the septum, attenuated both ends, (18.5–)24.6–36 × 2.2–2.9 µm, guttulate, hyaline.

Specimen examined—**TURKEY, Bolu Province: Yedigöller National Park**, 40°93′58″N 31°75′39″E, 1083 m asl, on living leaves of *Viscum album* subsp. *abietis* (Wiesb.) Abrom. (*Santalaceae*), 02.08.2019, G. Doğan (AEUT GD 2014).

Distribution—Austria/Italy (Winter 1883, as *Septoria visci*); Germany (Diedicke 1914); Hungary (Geza & al. 2009, as *Septoria visci*); Italy (Farr & Rossman 2020, as *Septoria visci*); Serbia and Bosnia and Herzegovina (Stanivuković & al. 2010, as *Septoria visci*).

Notes: Biological control of parasites by using plant pathogens has gained acceptance as a practical, safe and environmentally beneficial management method applicable to agro-ecosystems (Charudattan 2001). Control of European mistletoe is a major problem for the forest service in Turkey (Yüksel & al. 2005). More than 20 microscopic fungi live on European mistletoe, but only a few of them cause major damage on the plant (Karadžić & al. 2004). Of these, *Rhabdospora visci*, which causes leaf spot disease of European mistletoe, appears to have potential as a biological control agent against of this semiparasite.

This species was initially described as *Septoria visci* on leaves of *Viscum album* parasitising gymosperm trees in South Tyrol (Winter 1883). It was later transferred to the genus *Rhabdospora* by Diedicke (1914). Our specimen of *Rhabdospora visci* was morphologically similar to specimens described by previous studies (Winter 1883, Diedicke 1914) but differed in having slightly thicker and shorter conidia.

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Cribraria lepida, Physarum dictyosporum, P. diderma, and P. spectabile newly recorded from Turkey

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Abstract—The moist chamber technique was used to obtain *Cribraria lepida*, *Physarum dictyosporum*, and *P. diderma* from wood or bark at different outdoor localities in Karaman Province and *P. spectabile* in Konya Province. These taxa are reported for the first time from Turkey.

Key words—*Cribrariaceae*, *Mycetozoa*, myxobiota, *Physaraceae*, slime moulds

Introduction

The myxomycetes, or slime moulds (*Mycetozoa* or *Myxogastria*), are a group of ameboid protists, traditionally studied by mycologists. Martin & Alexopoulos (1969) considered the myxomycetes to represent fungi, but at various times they have been classified as animals, plants, or fungi (Ing 1994). Recently, Cavalier-Smith (2013), following zoological nomenclature, proposed a new classification of the myxomycetes based on evolutionary and phylogenetic evidence; myxomycetes are currently classified as *Myxogastria* in the super-class *Amoebozoa* and first rank *Eumycetozoa*. Fruiting bodies produced by amoeboid organisms are referred to as either sporocarps, developing from a single amoeboid cell (myxomycetes and protostelids), or sorocarps, developing from an aggregate of amoeboid cells (dictyostelids) (Adl & al. 2005). Myxomycetes form a monophyletic group within the *Amoebozoa* (Adl & al. 2018, Leontyev & al. 2019). Despite formal classification as *Amoebozoa*, myxomycetes will continue to be studied by mycologists, while

species classification will likely continue to follow the International Code of Botanical Nomenclature due to the practicality of retaining the system and difficulty in transitioning to another nomenclatural system (Keller & Everhart 2010). In this study, www.eumycetozoa.com was used to determine the nomenclatural status of the genera and www.mycobank.org was used for systematic information.

Myxomycetes are free-living predators of other eukaryotic protists and bacteria and have been recorded in every terrestrial habitat investigated to date (Stephenson & Rojas 2017). In addition to their abundance in the soil, they are abundant and more commonly studied in the overlying litter layer, decaying wood, the bark of living trees, or numerous other substrates associated with various decaying plant materials (Stephenson 2011, Walker & al 2019). Specimens for study can be obtained as fruiting bodies that have developed in the field under natural conditions or cultured in the laboratory (Stephenson & Rojas 2017).

Myxomycete research in Turkey is relatively recent. The first study of myxomycetes in Turkey was made by Lohwag (1957). Recently, interest in these extraordinary organisms has increased in Turkey and a total of 286 myxomycete species have been listed from Turkey (Baba & Sevindik 2019). This report covers Turkish records of four additional myxomycete species.

Materials & methods

During 2013–2018 field surveys were organized for two different projects in Karaman. The moisture chamber technique, applied to collected samples in the cultivated mushroom cultivation room, revealed three new records. A fourth new record was recovered from *Pleurotus ostreatus* culture logs (Hadim-Konya) on which different procedures were performed at the Fungarium of the S.U. Mushroom Application and Research Center. The physical conditions in the mushroom cultivation rooms are close to the moist chamber culture technique; temperature, humidity, and ventilation are automatically controlled as described by Eroğlu & al. (2019): 85–90% humidity; 17–22 °C temperature; 12 hours day and 12 hours night; 10 minutes per hour ventilation; and water vapor fogging for 5 seconds every half hour was automatic in the production room for *Pleurotus* cultivation on poplar logs. Myxomycete development requires higher temperatures (24–25 °C), but the other conditions are suitable.

Materials were examined under the stereo microscope daily and the developing samples were glued to cardboard with their substrates and left to dry in the laboratory. The specimens obtained were dried in the mycology laboratory and identified by myxomycete identification literature (e.g., Martin & Alexopoulos 1969, Neubert & al. 1993). Fungarium numbers were assigned after identification

and illustration of each specimen. During the identification procedure, samples were photographed with an imaging stereo microscope (SM) and a light microscope (LM). The specimens are deposited in the Mushroom Application and Research Center Fungarium, Selçuk University, Konya, Turkey (KONF).

Taxonomy

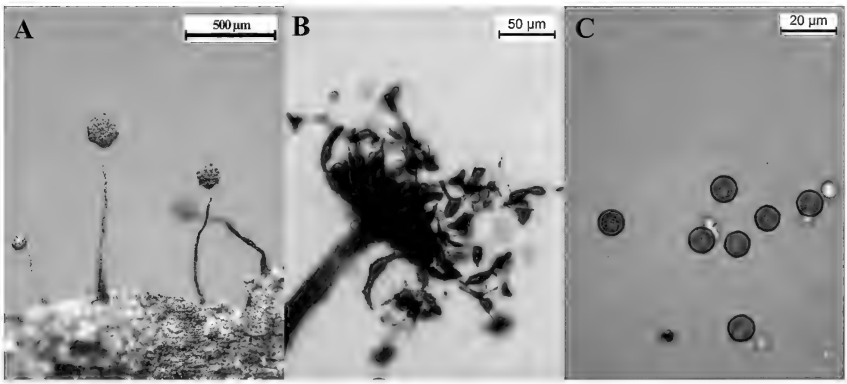

Fig. 1. *Cribraria lepida* (KONF GE141).
A. Sporocarps (SM); B. Peridial meshes and spores (LM); C. Spores (LM).

Cribraria lepida Meyl., Bull. Soc. Vaud. Sci. Nat. 56: 326. 1927. Fig. 1

Sporocarps gregarious, stalked. Sporotheca nodding, bright violet, 0.25–0.5 mm diam. Stalk dark violet, 2–5 mm long, 6–10 times the diameter of the sporocarp. Calyculus occupying one-third of the zoothecia, net bearing, prominent, thickened, pulvinate nodes. Dictydine granules deep purple, 0.5–1 µm. Spores minutely warted, violet in mass, pale lilaceous by light microscope, (5–)7–8 µm diam.

Specimens examined: **TURKEY. Karaman Province: Sarıveliler,** Civler village, 36.6680°N 32.5830°E, 1380 m, on debris wood of *Pinus* sp., 14.11.2015 (KONF GE141); **Dumlugöze**, 36.5583°N 32.6017°E, 880 m, on debris wood of *Pinus* sp., 01.07.2016 (KONF GE291); **Başyayla**, 36.7611°N 32.6694°E, 1594 m, 15.10.2016 (KONF GE403).

Comments—*Cribraria lepida,* which can have a color similar to that of *C. violacea* Rex, can be distinguished by the thickened nodes of the peridial reticulum. *C. purpurea* Schrad. has longer sporangia with a relatively short stalk and the dark violet granules are 2–3 (–5) µm diam. (Nannenga-Bremekamp 1991). *C. violacea* has angular, very large nodes. The nodes differ considerably: flattened in *C. violacea* and pulvinate in *C. lepida* (Ramírez-Ortega & al. 2017). *Cribraria lepida* has very long sporangial stalk and is

violet colored while *C. purpurea* is reddish violet or violaceous pink and has a shorter stalk.

Cribraria lepida has been reported from Europe, North and South America, and Asia [Vietnam, Philippines, Western Siberia] (Bernardo & al. 2018, Estrada-Torres & al. 2009, Lado & al. 2011, Martin & Alexopoulos 1969, Meylan 1927, Neubert & al. 1993, Novozhilov & al. 2017, Redeña–Sontos & al. 2018, Vlasenko 2015); here it is reported for the first time from Turkey.

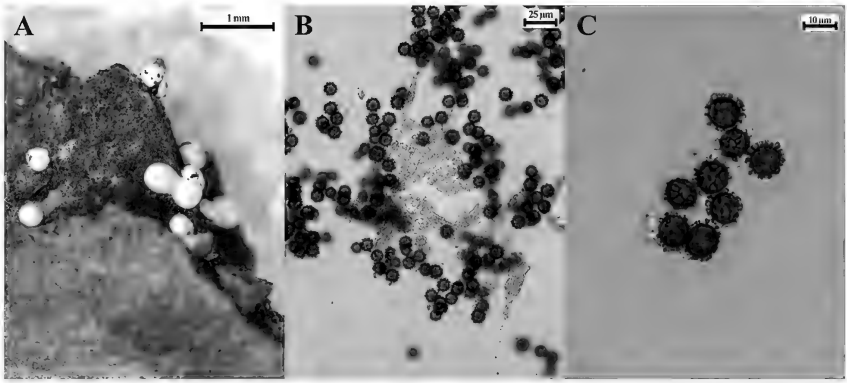

Fig. 2. *Physarum dictyosporum* (KONF GE102).
A. Sporocarps (SM); B. Capillitium and spores (LM); C. Spores (LM).

Physarum dictyosporum G.W. Martin, Brittonia 14: 183. 1962. Fig. 2

Fructification plasmodiocarpous, scattered with rounded and sessile sporangia, gregarious, 0.4–0.6 mm diam., 0.5–0.6 mm tall, the plamodiocarps ≤2.2 mm long, sinuous, very rarely branched, on inconspicuous dark brown hypothallus. Peridium double, the outer layer a limy crust, white, the inner peridium membranous, translucent, irregularly dehiscent. Capillitium abundant, the nodes white, angular and irregular in shape, connected by inconspicuous threads. Spores black in mass, violaceous brown in transmitted light, globose, 10–15 µm (mostly 10–11 µm) diam., the surface markings banded reticulate, with tall coarse dark warts connected by stout bands. Plasmodium white.

Specimens examined: **TURKEY. Karaman Province: Bucakkışla,** 36.9233°N 33.0278°E, 956 m, on bark of living *Pinus* sp., 06.06.2014 (KONF GE102); **Taşkale,** 37.1344°N 33.6072°E, 1378 m, on bark of living *Juglans* sp., 09.11.2014 (KONF GE305).

Comments—*Physarum echinosporum* Lister also produces white plasmodiocarpous sporocarps which, however, are laterally compressed, and

not terete as those of *P. dictyosporum* (Liu & al. 2013). *Physarum dictyosporum* has very distinctive spores but superficially resembles the cosmopolitan *Didymium difforme* (Pers.) Gray (Ing & Hnatiuk 1981).

Physarum dictyosporum has been reported from North and Central America, Africa [Seychelles], and Asia [India, Taiwan] (Alexopoulus & Sáenz 1975, Farr 1976, Ing & Hnatiuk 1981, Liu & al. 2013, Ranade & al. 2012, Rojas & al. 2018); here it is reported for the first time from Turkey.

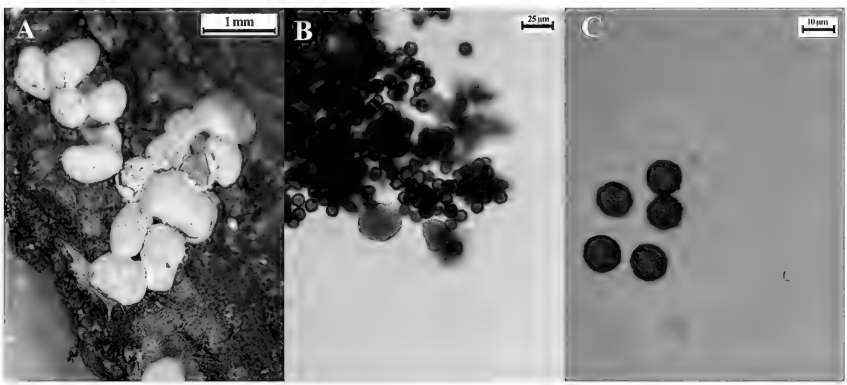

Fig. 3. *Physarum diderma* (KONF GE86).
A. Sporocarps (SM); B. Capillitium and spores (LM); C. Spores (LM).

Physarum diderma Rostaf., Śluzowce Monogr.: 110. 1875 ["1874"]. Fig. 3

Sporangia clustered, sessile or narrowly adnate, globose, pulvinate, about 1 mm. diam., snow-white. Peridium double, the outer layer dense, fragile, thick, calcareous, the inner delicate, translucent, membranous. Capillitium abundant, the nodes white, angular, sometimes uniting to form a pseudocolumella. Spores black in mass, purplish-brown in transmitted light, rough, 10–12 µm diam.

Specimens examined: **TURKEY. Karaman Province: Kazımkarabekir,** 37.205°N 32.9469°E, 1154 m, on bark of living *Quercus* sp., 17.05.2013 (KONF GE12); **Bucakkışla,** near Göksu river, 36.9508°N 33.0203°E, 421 m, on debris wood of *Pinus* sp., 06.06.2014 (KONF GE86).

Comments—*Physarum diderma* can be confused with *P. didermoides* (Pers.) Rostaf., *P. spectabile*, and *P. bitectum* G. Lister. The sporocarps of *P. didermoides* are sessile or stalked; when membranous stalked, the stalk often appears like a flattened extension of the hypothallus. *Physarum bitectum* sporocarps are slightly compressed laterally contrasting with the sessile globose sporocarps

of *P. diderma.* The capillitia of *P. didermoides* and *P. licheniforme* (Szabó ex Schwein.) Lado are small and rounded, in contrast to the large angular capillitium in *P. diderma* (Poulain & al. 2011).

Physarum diderma has been reported from Europe, North America, and Asia [Israel, India] (Eliasson & Adamonyte 2009, Harling 1952, Martin 1949, Novozhilov & al. 2006, Ukkola & al. 1996, Zoll & Stephenson 2015); here it is reported for the first time from Turkey.

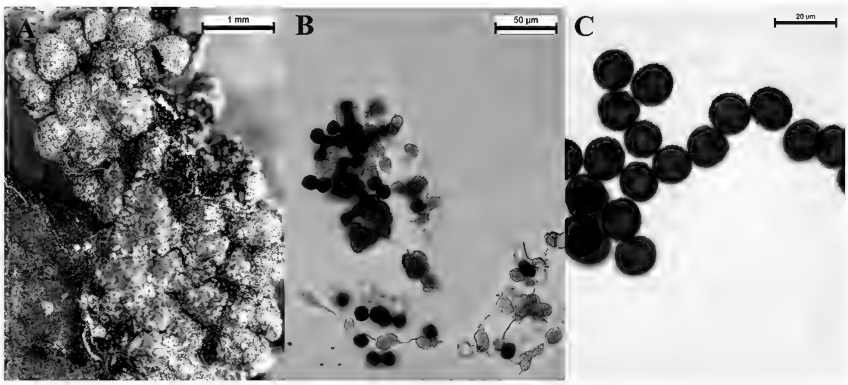

Fig. 4. *Physarum spectabile* (KONF GE747).
A. Sporocarps (SM); B. Capillitium and spores (LM); C: Spores (LM).

Physarum spectabile Nann.-Bremen., Lado & G. Moreno,
Proc. K. Ned. Akad. Wet., Ser. C, Biol. Med. Sci. 87(1): 91. 1984. Fig. 4

Sporangia sessile; crowded or scattered, sometimes heaped; flattened, pulvinate, on wide base; sporangia 0.5–0.7 mm diam., plasmodiocarps 1–2.5 × 0.5–0.7 mm, white. Peridium single, membranous, white or ash-gray, encrusted with granular white lime in upper part. Hypothallus membranous, translucent, inconspicuous. Stalk and columella absent. Capillitium comprising a small-meshed net of colorless fine tubes with many rounded, (sometimes oblong and branched) lime nodes, sometimes forming pseudocolumella. Spores dark brown or almost black in mass; dark purplish brown in transmitted light, angular in optical section, with pale narrow lines, 12–14 µm diam., densely ornamented regularly distributed warts.

Specimen examined: **TURKEY. Konya Province: Hadim**, Eğiste stream, 35.1083°N 32.4558°E, 1081 m, on bark of *Populus* sp. culture log of *Pleurotus ostreatus*, 18.10.2017 (KONF GE747); Eğiste stream, 37.10944°N 32.4575°E, 1095 m, on bark of *Populus* sp. culture log of *P. ostreatus*, 18.10.2017 (KONF GE755).

Comments—*Physarum spectabile* has very variable characters and may be either sessile or have a well–defined calcareous stalk. The species can be confused with *P. straminipes* Lister, which has a non–calcareous membranous extension of the hypothallus and not a stalk. Even when *P. spectabile* is sessile, the narrow pale bands on the usually angular spore separate *P. straminipes* from *P. atacamense* D. Wrigley & al. and *Badhamia melanospora* Speg. (Nannenga-Bremekamp & al. 1984, Lado & al. 2007, Estrada-Torres & al. 2009, Wrigley de Basanta & al. 2012, Gmoshinskiy & al. 2017). *Badhamia melanospora* has a completely different badhamioid capillitium with calcareous tubes in a network, not limeless tubes connecting small round lime nodes (Castillo & al. 1996, Moreno & Oltra 2010, Gmoshinskiy & al. 2017).

Physarum spectabile has been reported from Europe, North and South America, and Africa (Estrada-Torres & al. 2009, Gmoshinskiy & al. 2017, Kylin & al. 2013, Lado & al. 2007, Lizárraga & al. 2015, Nannenga-Bremekamp & al. 1984, Ndiritu & al. 2009, Oltra & Tejedor 2005, Xavier de Lima & Cavalcanti 2017, Yatsiuk & al. 2017); here it is reported for the first time from Turkey and from Asia.

Discussion

Cribraria was proposed by Persoon (1794); and *Cribraria* species are characterized by dictydine granules, peridium remaining as a net with without nodes, and sporangiate fruiting bodies consisting of stalked sporangia with or without basal cups (Liu & Chang 2007). According to Martin (1949), Martin & Alexopoulos (1969), and Nannenga-Bremekamp (1991), plasmodic granules, the lack of a capillitium, and the persistent surface net make *Cribraria* species easy to recognize (Ramírez–Ortega & al. 2009). The plasmodic granules of *Cribraria* are also referred to as dictydine granules (Martin & Alexopoulos 1969, Keller & Braun 1999, Stephenson 2003), calcareous dictydine granules (Ing 1999), lime globules (Nannenga-Bremekamp 1991) or calcic granules (Discover Life 2020).

Physarum was also proposed by Persoon (1794). The name was coined based on the bubble-like appearance of the sporangium (Ranade & Ranadive 2016). The single most important character in *Physarum* is the presence of lime (calcium carbonate) deposits that may occur in the peridium, capillitium, or sporothecal stalk (Stephenson & Stempen 2000). With about 149 taxa worldwide, *Physarum* is the largest myxomycete genus (Lado 2020) and the most widely known genus among the myxomycetes (Hoppe & al. 2010).

According to the literature, myxomycetes have been reported as a weak disease on fungi growing on culture stumps (Chung & al. 1998, Lee & al. 2014). However, according to these authors, myxomycetes are not pathogenic, rather consuming mushroom hyphae and spores as food. Although there are studies on myxomycetes developing on cultures elsewhere (Chung & al. 1998, Desrumaux & al. 2003), none were detected in Turkey. Although *Physarum spectabile* generally commonly occurs on cacti and succulent plants (Nannenga-Bremekamp & al. 1984), the species is reported here for the first time on mushroom culture logs.

Acknowledgments

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First report of *Podosphaera cercidiphylli* on endangered *Cercidiphyllum japonicum* in China

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Abstract—A powdery mildew collected from the protected and endangered species *Cercidiphyllum japonicum* was identified morphologically as *Podosphaera cercidiphylli*, an identification confirmed by sequence analyses of the internal transcribed spacer (ITS) and large subunit (LSU) of nuclear ribosomal DNA (nrDNA). This is the first report of *P. cercidiphylli* in China.

Key words—*Ascomycota, Cercidiphyllaceae, Erysiphaceae,* taxonomy

Introduction

Podosphaera Kunze (*Erysiphaceae*, *Helotiales*) is a large genus with 62 species and 13 varieties worldwide, including 39 species native to Europe (Braun 1987, 1995). Thirty-six species have been reported from Japan (Nomura 1997), 16 species from Korea (Shin 2000), and 42 species (plus five varieties) from China (Tang & al. 2018). Within China, nine species and two varieties in *P.* sect. *Podosphaera* are known to infect 26 hosts (representing 10 genera and three families), while 33 species and three varieties in *P.* sect. *Sphaerotheca* are pathogens of 115 different hosts (representing 65 genera in 19 families) (Tang & al. 2018).

Cercidiphyllum japonicum Sieb. & Zucc. (*Cercidiphyllaceae*) is a plant endemic to eastern Asia, found in only a few Asian countries including China and Japan (Pan & Liu 1999). In China, *C. japonicum* is classified as an endangered species protected for its dioecism and extremely low regeneration rate, with natural populations distributed only sporadically in mixed forests of the warm temperate zone and subtropical mountains (Zeng & al. 2020). Unfortunately, plant diseases and insect pest attack threaten *C. japonicum,* with additional environmental stress. Our research revealed that both powdery mildew and mites (*Eriophyidae*) had jointly infected *C. japonicum* trees with the chasmothecia tending to obscure patches of cell hyperplasia caused by mites. This fungus was not easy to detect as the powdery white symptoms were inconspicuous. When we discovered cell hyperplasia in *C. japonicum,* we determined that this pathogen is new to China.

Materials & methods

Collection procedures & morphological examination

Samples of *Cercidiphyllum japonicum* leaves damaged by powdery mildew and mites were collected during 2018–2020 in Ankang City, southern Shaanxi Province, China. Herbarium specimens with chasmothecia were dried in plant presses and deposited in the Mycological Herbarium of Forestry College, Northwest A & F University, Yangling, Shaanxi Province, China (HMNWAFU-CF), and the Herbarium Mycologicum Academiae Sinicae, Beijing, China (HMAS).

Chasmothecia were picked carefully from the leaves, mounted in distilled water on a glass slide, and examined under an Olympus CX41 light microscope. Their colour, shape, cell wall surface, appendage position, length, apex branching, septum, shape, size, and numbers of asci and ascospores were observed and documented in detail. We checked 50 chasmothecia taken randomly from specimens and calculated averages and standard deviations using Microsoft Excel 2019.

Black-and-white images of the fungal teleomorph and mites were produced with a Nova NanoSEM 450 field emission scanning electron microscope according to Pathan & al. (2008). Partial photochromes were obtained by microphotographic focus stacking using a Lumix DMC-G8M camera fitted with Lumix 100–300 mm F4–5.6 φ67 mm and Mitutoyo M Plan Apo L 10×/0.28 ∞/0 f=200 lenses, M26 to M67 adapter, Wemacro Rail®, and Helicon® Focus 7 and Zerene Stacker® software (see https://www.wemacro.com/).

DNA extraction

Genomic DNA was extracted from the chasmothecia with BioRad Chelex-100 following published procedures (Walsh & al. 1991, Hirata & Takamatsu 1996, Bai

& al. 2014). Twenty–thirty chasmothecia were picked using a sterilized dissecting needle under a dissecting microscope and mounted onto microslides. A coverslip was used to squeeze the chasmothecia gently until broken, both slides and coverslip were rinsed gently with 50 µL 5% Chelex-100 sterilized water solution into a 1.5 mL centrifuge tube, which was placed into a 56 °C water bath for 20 min and then centrifuged at 5000 rpm for 1 min; the tube was then placed in a 100 °C water bath for 8 min, vortexed vigorously, and centrifuged for 1 min at 15000 rpm. The supernatant was transferred into another tube to be used as the template DNA.

PCR amplification

The nrDNA ITS region was amplified by nested PCR methods using ITS5 (White & al. 1990) and P3 (Kusaba & Tsuge 1995) as the first primer pair and ITS4 (White & al. 1990) and PM5 (Takamatsu & Kano 2001) as the second pair in 20 µL volumes containing 10 µL 2× CoWin Taq PCR MasterMix, 1 µL each Shanghai Sangon Biotech primer, 2 µL extracted DNA (65.9 ng/µL), and 6 µL ddH_2O. The samples were processed in a Bioer GeneAmp PCR TC-96 beginning with a 4-min initial denaturation at 95 °C, 35 cycles of 1-min denaturation at 94 °C + 1 min at 50 °C (1 min at 60 °C for the second pair of primers) + 1 min at 72 °C, and a final 10-min extension at 72 °C, with the procedure ending at 4 °C.

The nrDNA large subunit (LSU)/28S region was amplified with the primers LSU1 and LSU2 (Scholin & al. 1999) at the same volume (20 µL) and under the same amplification conditions as the previous pair of primers ITS5 and P3. The PCR products were separated by electrophoresis on a 1% agarose gel in TAE buffer and purified using the Bioteke Zymoclean™ Gel DNA Recovery Kit according to the manufacturer's instructions. The purified DNA products were amplified again as depicted above, and the PCR products were then sequenced by Shanghai Sangon Biotech Co., Ltd.

Phylogenetic analysis

Sequences were revised in BioEdit 7.2.5, BLAST searched in NCBI, and deposited in GenBank (MN960597, MN960655). Other homologous sequences from the GenBank database were downloaded for further comparisons. DNA sequences were aligned using ClustalX vers. 1.8. (http://www-igbmc.u-strasbg.fr/BioInfo/); gaps or missing data were eliminated from the datasets.

A neighbor-joining (NJ) tree inferred from ITS and LSU sequences was constructed using MEGA X (https://www.megasoftware.net/home) with the K2+G model. Maximum-parsimony (MP) and maximum-likelihood (ML) were generated with PAUP 4.0b10 (http://phylosolutions.com/paup-test/) as described by Jiang & al. (2011) and RAxMLGUI 2.0 (Edler & al. 2021) under a GTR+GAMMA model. Bootstrap percentages (BP) derived from 1000 replicates are indicated at the tree nodes.

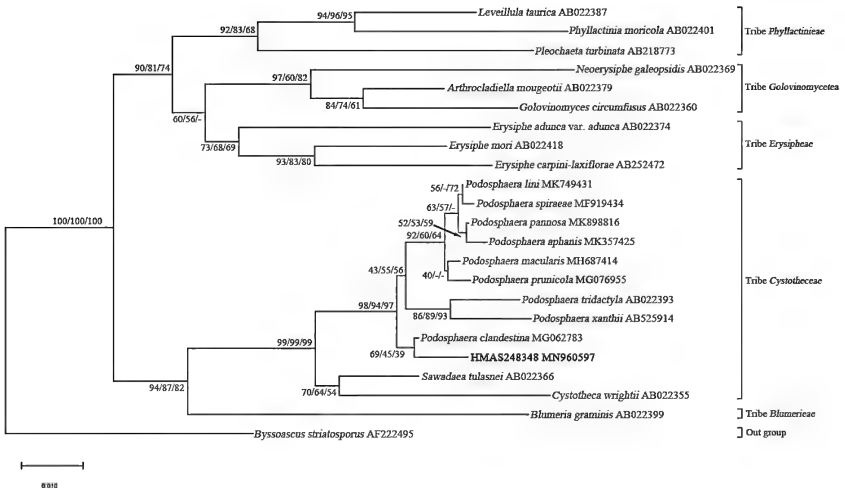

FIG. 1. Topological phylogram inferred from LSU rDNA from 21 taxa of *Erysiphaceae* with *Byssoascus striatosporus* as outgroup. Bootstrap percentages from methods of neighbor-joining (NJBPs), maximum-parsimony (MPBPs), and maximum-likelihood (MLBPs) are indicated at nodes.

Results

LSU rDNA phylogenetic analyses

PCR amplification with LSU primers produced a unique 550 bp sequence. The BLAST search revealed that HMAS 248348 had a high similarity to *Podosphaera* spp. The phylogenetic tree (FIG. 1) clustered HMAS 248348 in tribe *Cystotheceae,* separating it from the other tribes in *Erysiphaceae* with strong bootstrap supports (NJBP = 99%, MPBP = 99%, MLBP = 99%). It was closely related to *P. clandestina* with a 69-scored NJBP support.

ITS nrDNA phylogenetic analyses

After amplification with the ITS5/P3 primer pair, no obvious electrophoresis products were observed due to low PCR yields. Those amplicons served as the template for the ITS4/PM5 primer pair for nested PCR, which produced a unique 450 bp sequence as checked with gel electrophoresis. That sequence was aligned with 17 GenBank sequences of tribe *Cystotheceae.* ITS nrDNA phylogenetic analyses (FIG. 2) clustered HMAS 248348 and *Podosphaera cercidiphylli* in a monophyletic clade with

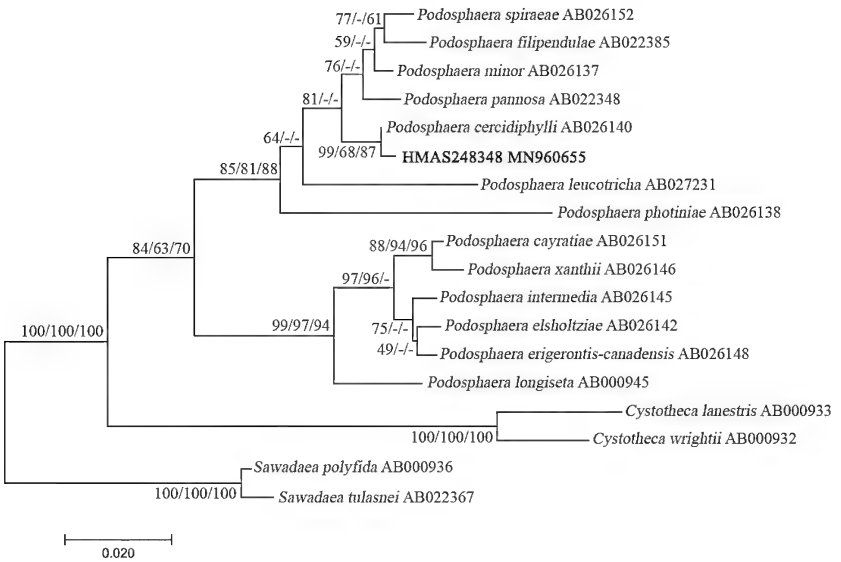

FIG. 2. Topological phylogram inferred from ITS sequences from 17 taxa of *Erysiphaceae* tr. *Cystotheceae* with two *Sawadaea* taxa as outgroup. Bootstrap percentages from methods of neighbor-joining (NJBPs), maximum-parsimony (MPBPs), and maximum-likelihood (MLBPs) are indicated at nodes.

fairly strong bootstrap supports (NJBP = 99%, MPBP = 68%, MLBP = 87%). Therefore, we identified HMAS 248348 as *P. cercidiphylli*.

Taxonomy

Podosphaera cercidiphylli Tanda & Y. Nomura,
Trans. Mycol. Soc. Japan 27: 25. 1986. FIG. 3

Mycelia amphigenous in epidermal hyperplasia caused by mites (*Eriophyes* sp.), mostly hypophyllous, evanescent or subpersistent, powdery layer not obvious; mites aggregating on epidermal hyperplasia, massive ecdyces of melts visible in patches; chasmothecia mostly scattered or subgregarious on epidermal hyperplasia, rarely scattered epiphyllously, brown or dark brown, lighter colour incipiently, globose or subglobose, 53.8–79.0 (average 67.0 ± 7.4) μm diam., wall cells irregularly polygonal, 6.9–18.9 × 10.4–23.8 (av. 11.4 ± 3.0 × 15.7 ± 3.1) μm; appendages 2–9 (mostly 3–7, av. 5 ± 1.8), produced

from the upper to equatorial part of the chasmothecia, radial, straight or arcuately curved, thick-walled throughout, 1–3 times longer than the chasmothecial diam., 70.9–226.0 (av. 129.2 ± 40.8) μm long, 5.3–9.3 (av. 7.1 ± 0.9) μm wide at the slightly thicker base, 3.3–7.2 (av. 5.3 ± 0.9) μm wide at the upper part, 1–6(–7)-septate, 2–5 times dichotomously branching at the apex, coloured dark brown from below the branch downward, ultimate branches short and obtuse, recurved or rarely straight; ascus single, subglobose to broadly ovate, sessile, double-walled, 41.3–62.6 × 49.6–69.1 (av. 53.5 ± 4.9 × 60.7 ± 4.9) μm; ascospores 8, oblong or ellipsoidal, 8.9–15.4 × 14.2–24.9 (av. 12.6 ± 1.9 × 19.1 ± 2.7) μm.

Specimens examined: **CHINA. Shaanxi Province: Ankang city**, Zhenping County, 32.1°N 109.2°E, alt. 1024 m, on living leaves of *Cercidiphyllum japonicum*, July 2018, Zhong-dong Yu (HMNWAFU-CF 2018017); July 2019, Zhong-dong Yu & Zi-jia Peng (HMAS 248348, GenBank MN960597, MN960655); Ningshan County, 33.4 °N 108.5°E, alt. 1649 m, on living leaves of *C. japonicum*, September 2020, Zhong-dong Yu & Zi-jia Peng (HMNWAFU-CF 2020021)

Distribution: Ankang city, Shaanxi Province, China; Hokkaido and Niigata Prefectures, Japan.

Discussion

Cercidiphyllum japonicum is distributed in China and Japan, and *Podosphaera cercidiphylli* (*P.* sect. *Podosphaera*) was originally described from Japan (Tanda & Nomura 1986). Here, we provide the first report from China based on morphological and phylogenetic characters; no anamorphic forms (neither mycelial layer nor conidia) were found. Tanda & Nomura (1986) cited 1–5-septate appendages arising from the basal region of the perithecium, but our Chinese specimens usually developed 1–7-septate appendages from the upper half of the equatorial region of chasmothecia, with each appendage dichotomously branched at a right or obtuse angle, and with each branch slightly shorter than the older one. However, Tanda & Nomura (1986) showed appendages dichotomously developing at a right angle with nearly an identical length for the consecutive branches. We found that there were usually eight ascospores in a single ascus instead of seven to eight ascospores as reported by Tanda & Nomura (1986). We believe that these differences are attributable to variable intraspecific development, possibly resulting from different observation methods and weather conditions at sampling sites.

Additionally, we are the first to observe a co-infection of *Cercidiphyllum japonicum* by *Podosphaera cercidiphylli* and mites. Chasmothecia were

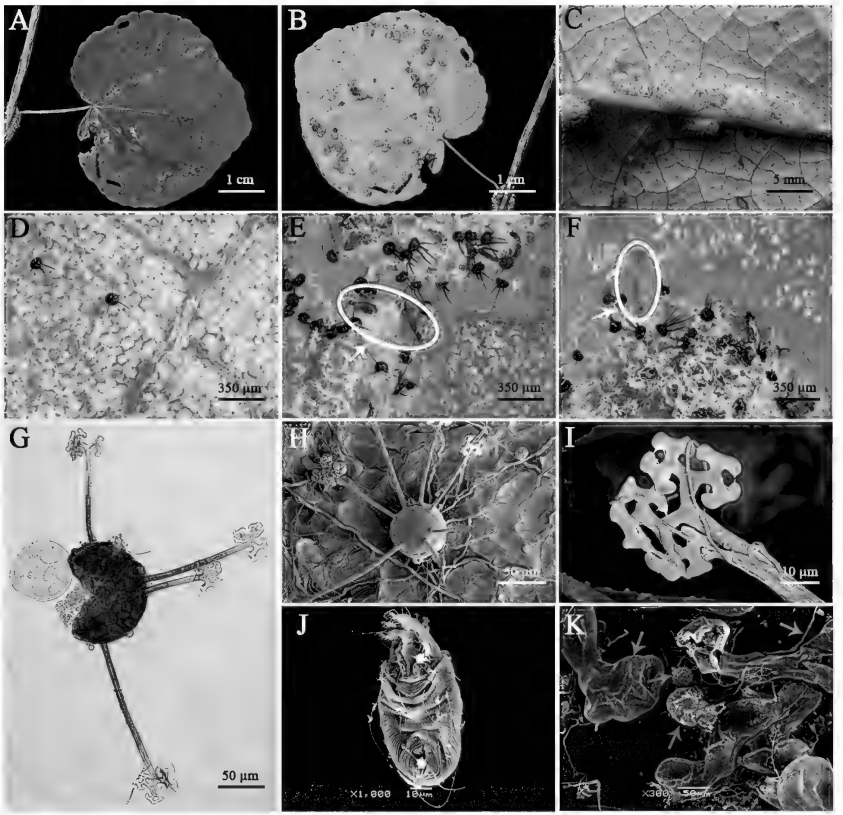

FIG. 3. *Podosphaera cercidiphylli* (HMAS 248348), teleomorphic characteristics and mites in the curled leaf: A–C. Symptoms of powdery mildew on leaf of *Cercidiphyllum japonicum*; D. Mycelia and chasmothecia; E, F. Ecdyces of mites (white arrow) and chasmothecia; G. Ascus, ascospores, and appendages; H. Insertion position of appendages; I. Dichotomous branch of appendages; J. Mite; K. Hyperplastic epidermal cells of leaf (red arrow), mycelia (purple arrow), mite (green arrow) and young chasmothecia (yellow arrow). Scale bars: A, B = 1 cm; C = 5 mm; D–F = 350 μm; G, H, K = 50 μm; I, J = 10 μm.

mainly distributed on the abaxial surface of leaves, most of which obscure patches of cell hyperplasia caused by mites. A *Podosphaera* species associated with mites was reported by Zheng & Yu (1987) occurring on *Betula pendula* Roth and *B. tianschanica* Rupr. infected by *P. erineophila* Naumov (Jaczewski 1927), but the intimate correlation between this powdery mildew and mites is not clear. We did not find the anamorphic stage of *P. cercidiphylli* on our specimens (in contrast to the Japanese specimens of Tanda & Nomura

1986); we speculate that either conidia had not been produced or that mite grazing had completely removed them. This is the first report of *Podosphaera cercidiphylli* in China.

Acknowledgments

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October–December 2021—Volume 136, p. 875

https://doi.org/10.5248/136.875

Regional annotated mycobiota new to the Mycotaxon website:

Abstract—The beautifully illustrated 30-page "Macromycetes from woodland zones of Milpa Alta mayoralty, Mexico City, Mexico" by Sierra and eleven co-authors may now be downloaded from Mycotaxon's mycobiota webpage. This brings to 151 the number of free-access Fungae uploaded or linked to

http://www.mycotaxon.com/mycobiota/index.html

NORTH AMERICA

Mexico

Sigfrido Sierra, Sandra Castro-Santiuste, Ibeth Rodríguez-Gutiérrez, Areli E. González-Mendoza, Mario Aarón Gutiérrez-Sánchez, Lisette Chávez-García, Daniela Abigail Guzmán-Ramírez, José de Jesús Ruiz-Ramos, Guadalupe Galván-Becerril, Navith Alejandra López-Garduza, Lilia Pérez-Ramírez, Joaquín Cifuentes. Macromycetes from woodland zones of Milpa Alta mayoralty, Mexico City, Mexico. 27 p.

Abstract— Previous studies about macromycete diversity in the Milpa Alta mayoralty demonstrated the presence of only one species (*Amanita aspera* var. *franchetii*). To update records from this region, specimens were collected in woodland areas during the rainy seasons (June-October) from 2008 to 2017. A total of 225 specimens were collected in 32 localities across different elevations and vegetation types. Specimens were morphologically identified with specialized literature. The macromycetes studied include 82 species, 59 genera, and 36 families. There is one new record for the country (*Calyptella campanula*) and 29 for Mexico City, and all the species are new to the mayoralty. Reference material was deposited in the Herbarium of the Sciences Faculty, UNAM, Mexico City (FCME). There are still unexplored localities in the area, so many more species are expected to be discovered.

Key words—*Ascomycota, Basidiomycota,* Sierra Chichinautzin, taxonomy, Trans-Mexican Volcanic Belt

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Regional annotated mycobiota new to the Mycotaxon website:

Abstract—The 10-page "A checklist of *Agaricus* from Pakistan" by Niazi, Ghafoor, and Bashir may now be downloaded from Mycotaxon's mycobiota webpage. This brings to 152 the number of free-access Fungae available on

http://www.mycotaxon.com/mycobiota/index.html

INDIAN SUBCONTINENT

Pakistan

Abdul Rehman Niazi, Aneeqa Ghafoor, Hira Bashir. A checklist of *Agaricus* from Pakistan. 10 p.

Abstract—We present a comprehensive checklist of the Agaricus species recorded from various regions of Pakistan. Thirty-two species are documented from Pakistan according to published reports and the latest literature. Orthographic variants and misidentified species have been excluded.

Key words—*Agaricaceae,* diversity, distribution, systematics, mycobiota

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Book reviews and notices*

Else C. Vellinga

861 Keeler Avenue, Berkeley CA 94708, USA

Abstract—We are pleased to recommend "Common edible and poisonous mushrooms of southwestern China" by Yang, Wu, Li, Wang, and Cai. (2021).

Common edible and poisonous mushrooms of southwestern China. By Z-L. Yang, G. Wu, Y-C. Li, X. Wang, Q. Cai, 2021. Science Press, Beijing, China. 198.00 ¥, https://life.sciencereading.cn 370 p with color plates. Hardback, in Chinese and English. ISBN 978-7-03-068388-5.

One of the nice things to do for a mycologist traveling in Southeast Asia is a visit to the local market to marvel at the displays of locally collected mushrooms for sale. All those species—various boletes, *Amanita, Termitomyces,* and many others—and all in one place. Names are of course only in the local languages, and one has to dive into the scientific literature to find answers for one's questions. Fortunately, there are now several books available to help the myco-traveler getting to know the edible and poisonous mushrooms of the area. In 2019 An introduction to the edible, poisonous and medicinal fungi of northern Laos was published, reviewed here by Vellinga (2019), and a large volume on poisonous mushrooms for China finally saw the light in 2016 (Chen & al. 2016).

* Book reviews or books for consideration for coverage in this column should be sent to the Editor-in-Chief <editor@mycotaxon.com> 6720 NW Skyline, Portland OR 97229 USA.

The book on common edible and poisonous mushrooms discussed here focuses on one region of China only—the southwest, covering Tibet; the provinces of Yunnan, Sichuan, and Guizhou; and the municipality of Chongqing; this region is extremely varied, in topology, climate, and habitat.

The introduction is relatively short, only 25 pages, and focuses on the region, the difficulties distinguishing edible species from their toxic look-alikes, preventing and treating poisonings, descriptive terms of the mushrooms, and the various groups and how to key those out. A key to the main groups is included, but not one to the species.

The main section is dedicated to the species themselves, and for each species a photo taken in the wild (a very few photos are taken outside the natural setting) is given, complemented by a description and an end note regarding edibility or toxicity. The species are ordered according to their general morphology (gilled mushrooms, boletes, polypores, etc.), and edible and poisonous species are not in separate parts. This arrangement gives the reader a better idea about how similar poisonous species can be to edible ones. To give an idea about the coverage, 60 bolete species and 30 amanitas are included. and *Termitomyces* is represented by nine species. Nomenclature is in general up to date (although *Cystoderma aureum* is still in *Phaeolepiota*), and the plates and descriptions are of high quality.

161 纯黄白鬼伞
Leucocoprinus birnbaumii (Corda) Singer
Pileus 1–6 cm in diam., long ovoid when young, applanate when mature, center umbonate, surface yellowish to yellow, covered with yellowish to yellow squamules, margin radially striate; context yellowish. Lamellae free, yellowish. Stipe 4–11 cm long, 0.4–0.8 cm in diam., subcylindrical, yellowish to yellow, tomentose, hazed enlarged; annulus superior, membranous, fugacious. Basidiospores 9–10.5 × 6–7.5 μm, ovoid-ellipsoid to amygdaliform; germ pore with cap.
On soil in forests, on compost or in flowerpot. Poisonous, causing gastroenteritis symptoms.
Descriptions and photos of common edible and poisonous mushrooms

A few final words. All the texts in this book are in Chinese and in English, which makes it very accessible and useful for those who don't read Chinese.

This book gives a very nice introduction to the very rich mycoflora/funga of southwestern China, but of course, only gives information on the edible and poisonous species. Nonetheless, as such it is a welcome addition to the Chinese mushroom book library.

Chen Z-H, Yang Z-L, Bau T, Li T-H. 2016. Poisonous mushrooms: recognition and poisoning treatment. Science Press, Beijing, China. 308 p.

Læssøe T, Sparre Pedersen O, Sysouphanthong P. 2019. An introduction to the edible, poisonous and medicinal fungi of northern Laos. 192 p.

Vellinga EC. 2019. Book reviews and notices. Mycotaxon 134: 583–590. https://doi.org.10.5248/134.583

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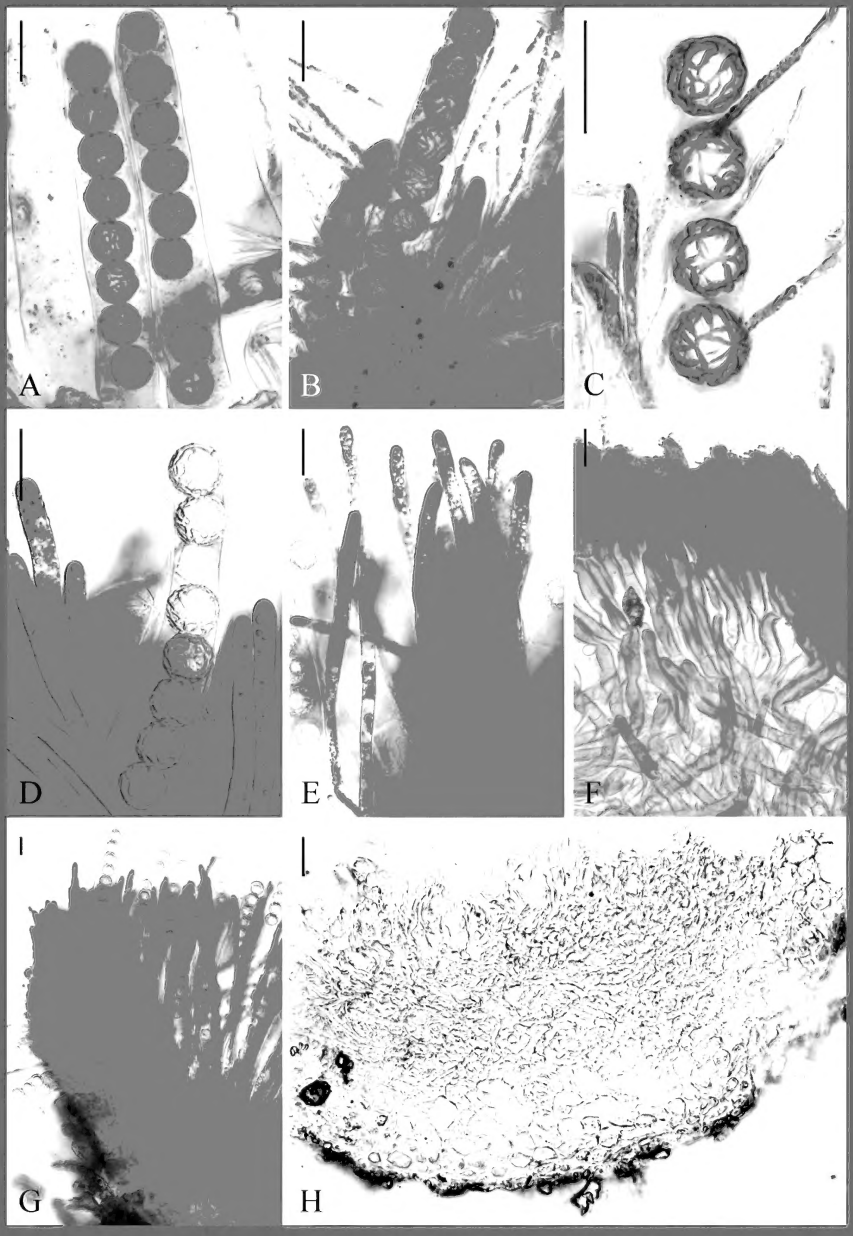

Lamprospora benkertii sp. nov.
(Eckstein & al.— Fig. 2, p. 699)